WATER POLLUTION CONTROL BUREAU

ENVIRONMENTAL IMPROVEMENT DIVISION

NEW MEXICO HEALTH AND ENVIRONMENT DEPARTMENT

WATER QUALITY DATA FOR DISCHARGES FROM NEW MEXICO URANIUM MINES AND MILLS

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NOTE TO THE READER:

This report was prepared in order to present data on water quality obtained by the State of New Mexico during routine sampling of uranium mines and mills by personnel of the Environmental Improvement Division. Each set of data is presented as reported from the analytical laboratories. In a very few cases, specific analyses, for whatever reasons, appear to be inconsistent with the rest of the data. However, these inconsistent analyses are included in the data set for the sake of completeness.

Specific information on quantities of barium chloride being added, water discharge rates, shaft depths, backfilling status and mine water recirculation status was obtained from the uranium companies, either from verbal reports by company officials (principally during the sampling visits) or from company documents.

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I. INTRODUCTION

A. PURPOSE AND SCOPE OF THIS REPORT

The purpose of this paper is to report on three years of water quality data obtained from samples collected by the New Mexico Environmental Improvement Division (EID) in 1977, 1978, and 1979 at all New Mexico uranium mines known to be undergoing dewatering (including discharge from uranium recovery facilities) and at all operating New Mexico uranium mills. In addition, data for samples collected at two locations from wells completed into the ore bearing formation in areas which are expected to undergo uranium recovery will be reported. For approximate locations of all facilities sampled see figures 1, 2, 3 and 4.

In order to provide a background for understanding the data, general information will be presented on 1) the location and geology of the major ore bodies, 2) the need for dewatering, 3) dewatering techniques and sources of water, 4) water treatment and 5) mine water inflow rates. A brief description of waste liquor generation during milling will be given. The methods used in sample collection will be described. The type of analysis used for each element will be outlined.

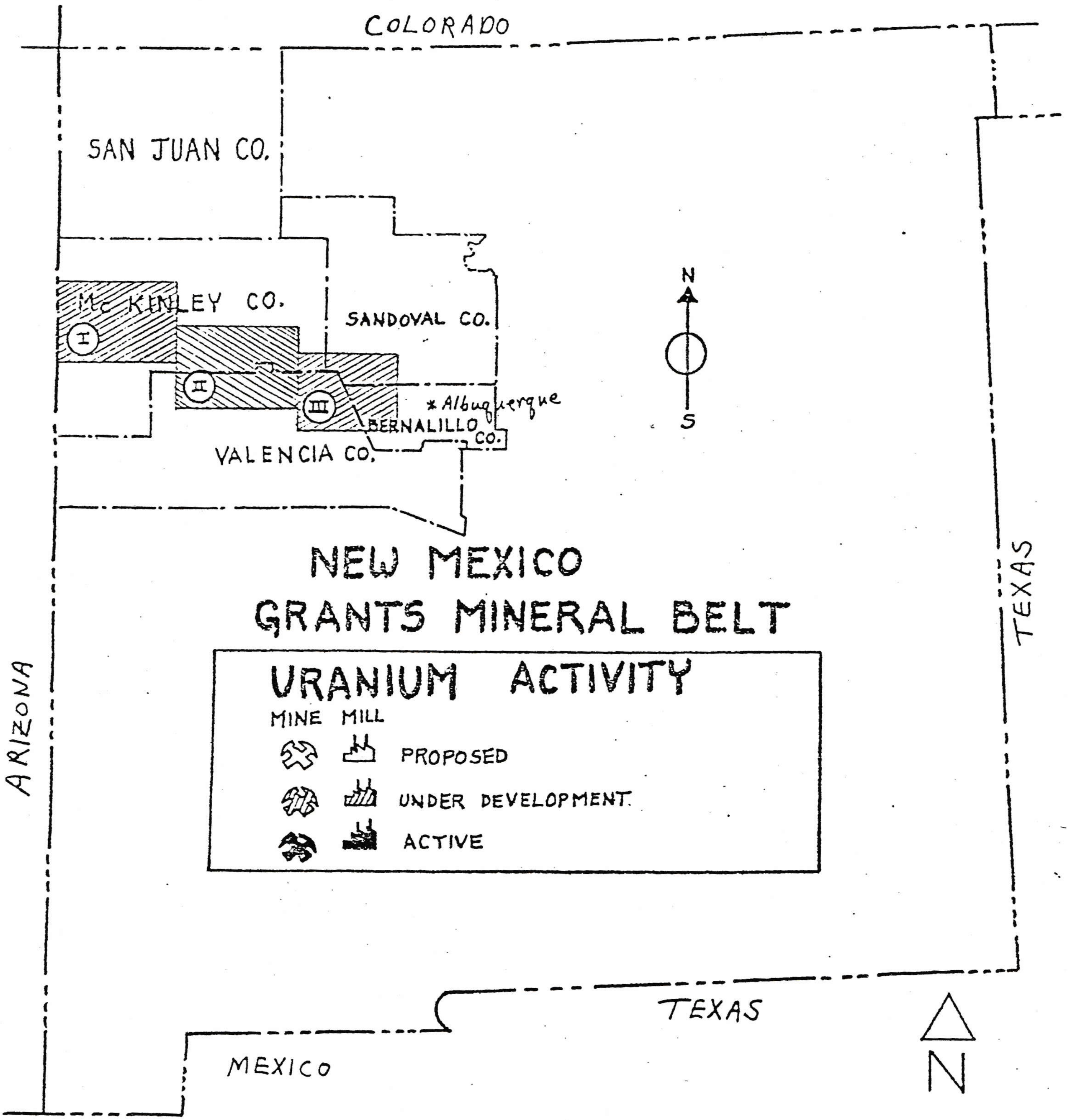

FIGURE 1 -- LOCATION OF NEW MEXICO GRANTS MINERAL BELT AND KEY TO SYMBOLS

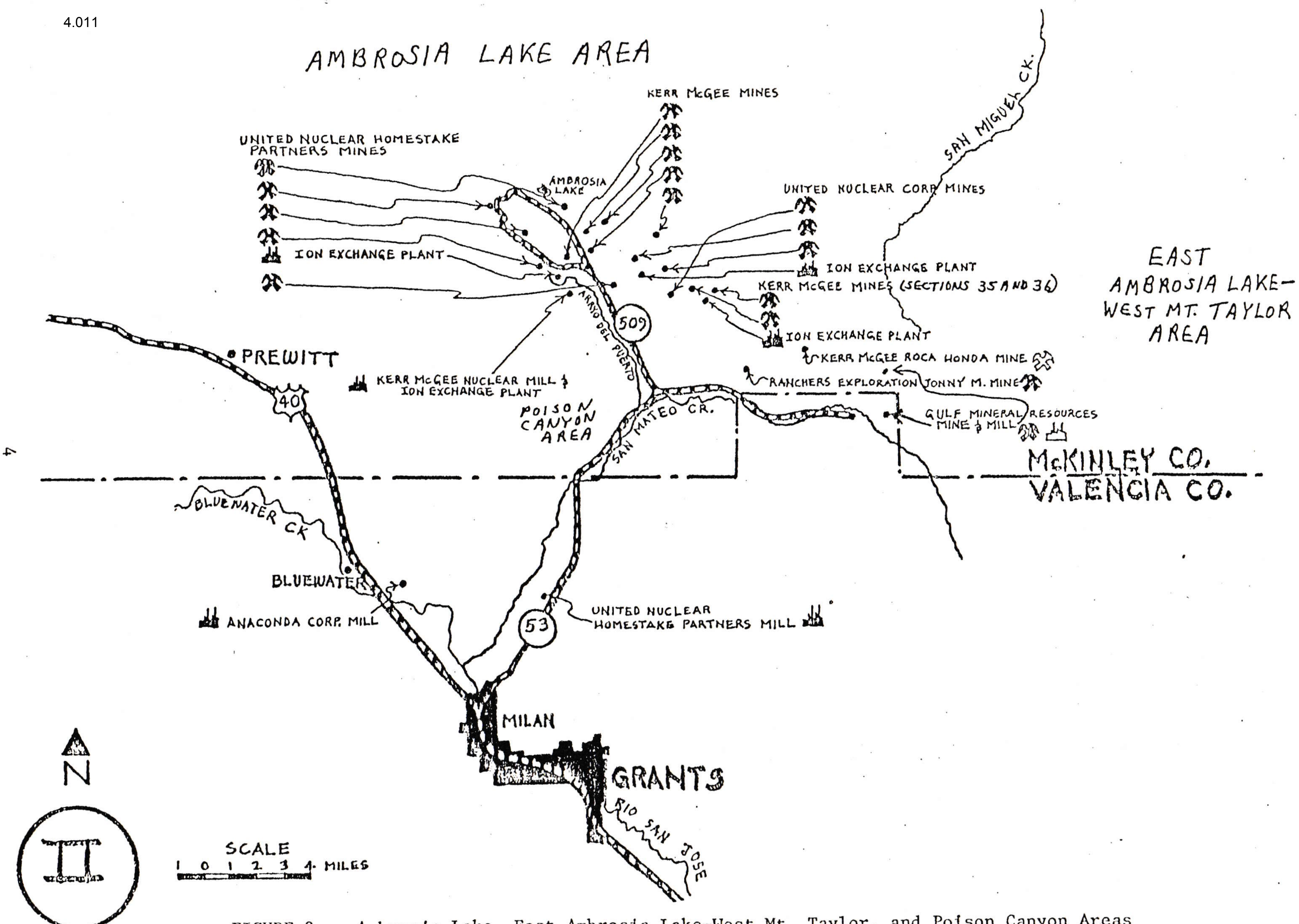

FIGURE 3 -- Ambrosia Lake, East Ambrosia Lake-West Mt. Taylor, and Poison Canyon Areas

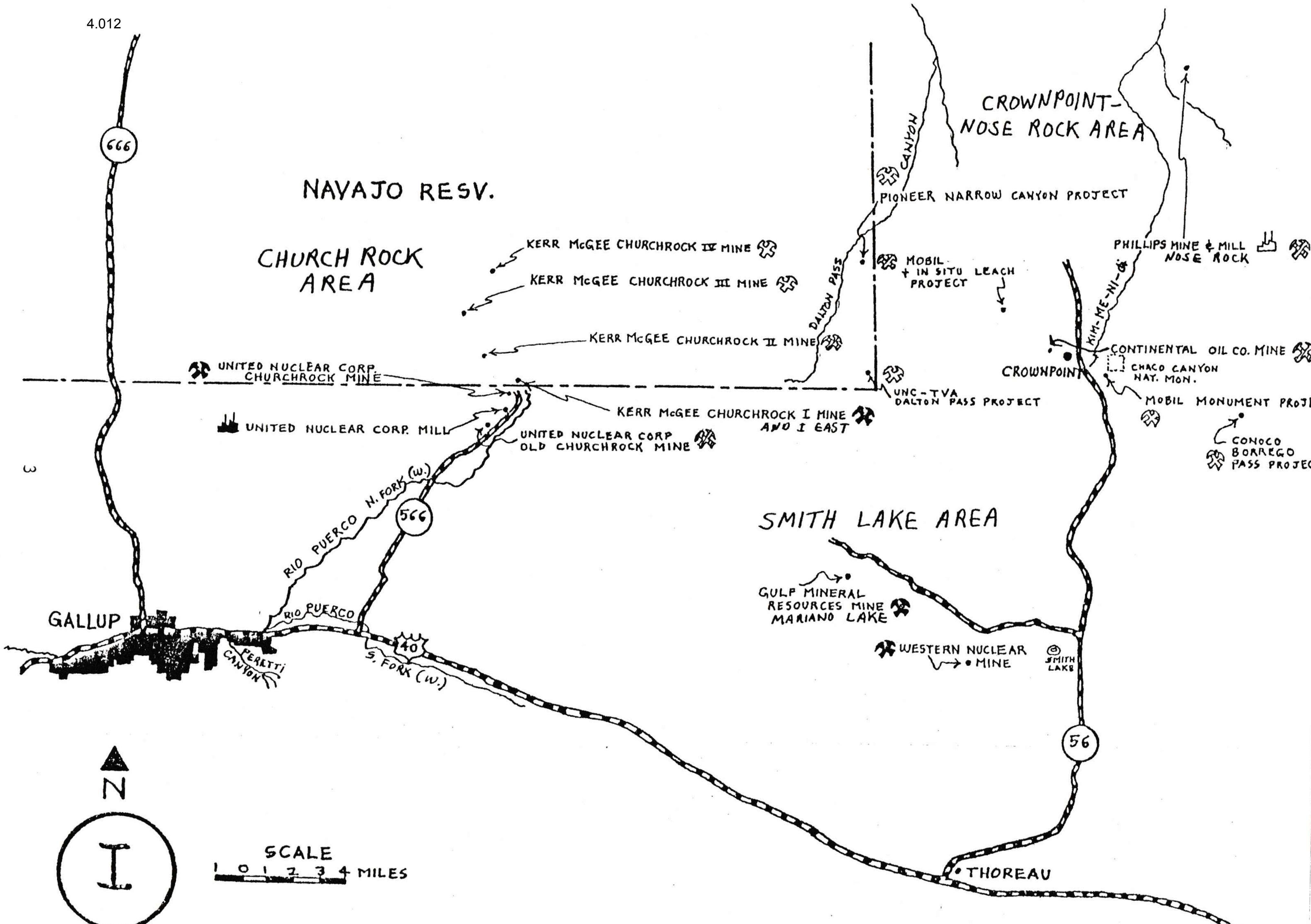

FIGURE 2 -- Church Rock, Smith Lake and Crownpoint-Nose Rock Areas

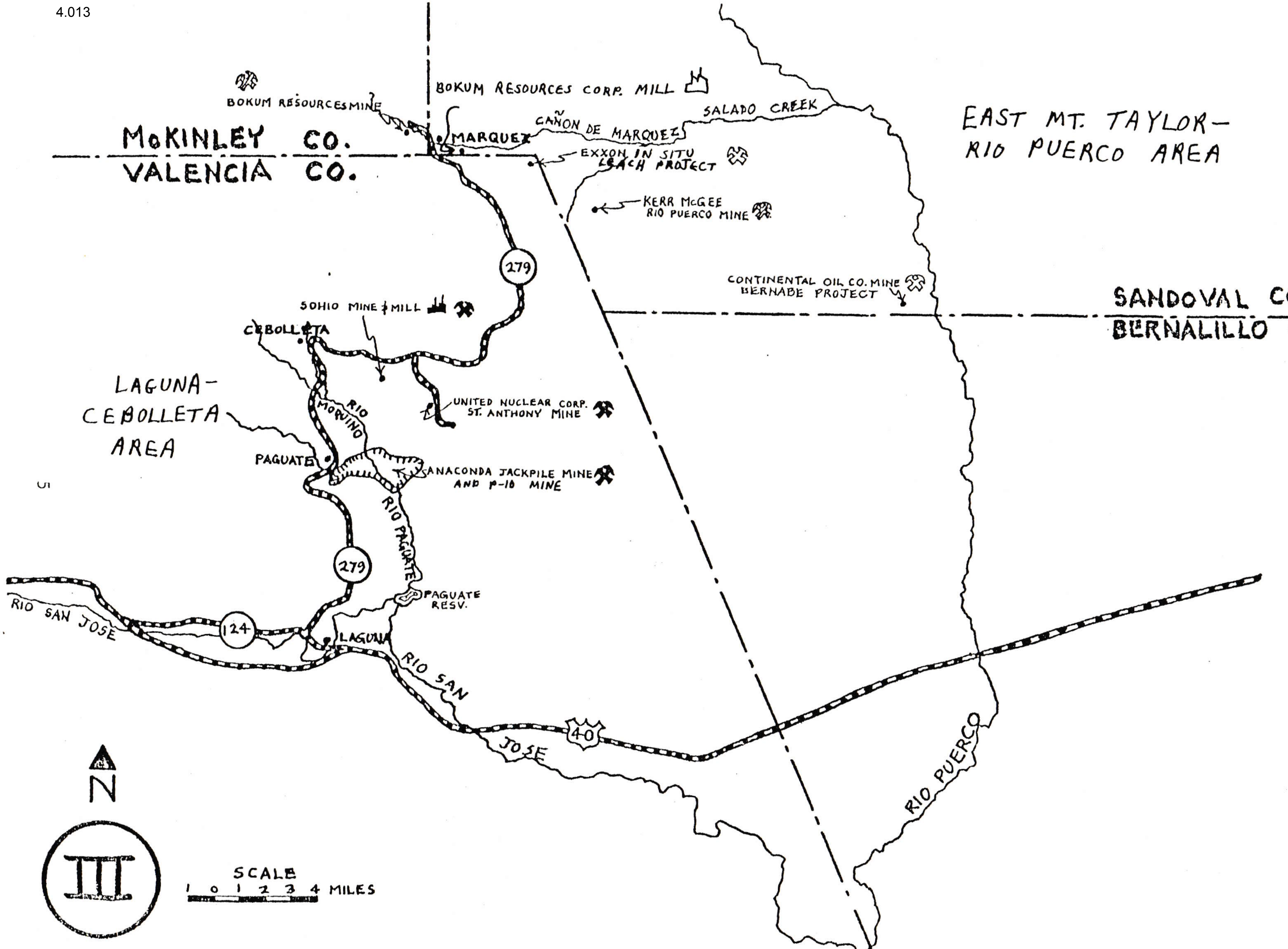

FIGURE 4 -- Laguna-Cebolleta and East Mt. Taylor-Rio Puerco Areas

Finally the tabulated data will be presented along with a narrative describing mine water treatment, type of mill circuit, etc. for each sampling location. The narrative will include, where available, data provided by the discharger on rates at which barium chloride is added to precipitate radium, in order that the data can be used to obtain a more complete understanding of treatment parameters.

B. BACKGROUND INFORMATION ON URANIUM MINES

Location and Geology of the Host Rock

As of 1/1/79 all but 3100 tons of the 473,900 tons U_3O_8 $50/lb forward cost reserves in New Mexico were located in the Morrison Formation in the structural San Juan Basin of Northwest New Mexico (figure 5).

The Morrison is generally considered to be of the Late Jurassic period. It is principally comprised of interbedded sandstone, claystone, or mudstone, some thin-bedded limestone, and some conglomerate. The sandstone units range from a foot or so to more than 100 feet in thickness, are arkosic, contain much interstitial clay or mudstone, and locally carbonized plant fragments and fossil logs.

The Morrison generally grades from conglomeratic sandstone in the southwestern part of the basin region to finer material, mostly mudstone, in the northeastern part. It has been divided into

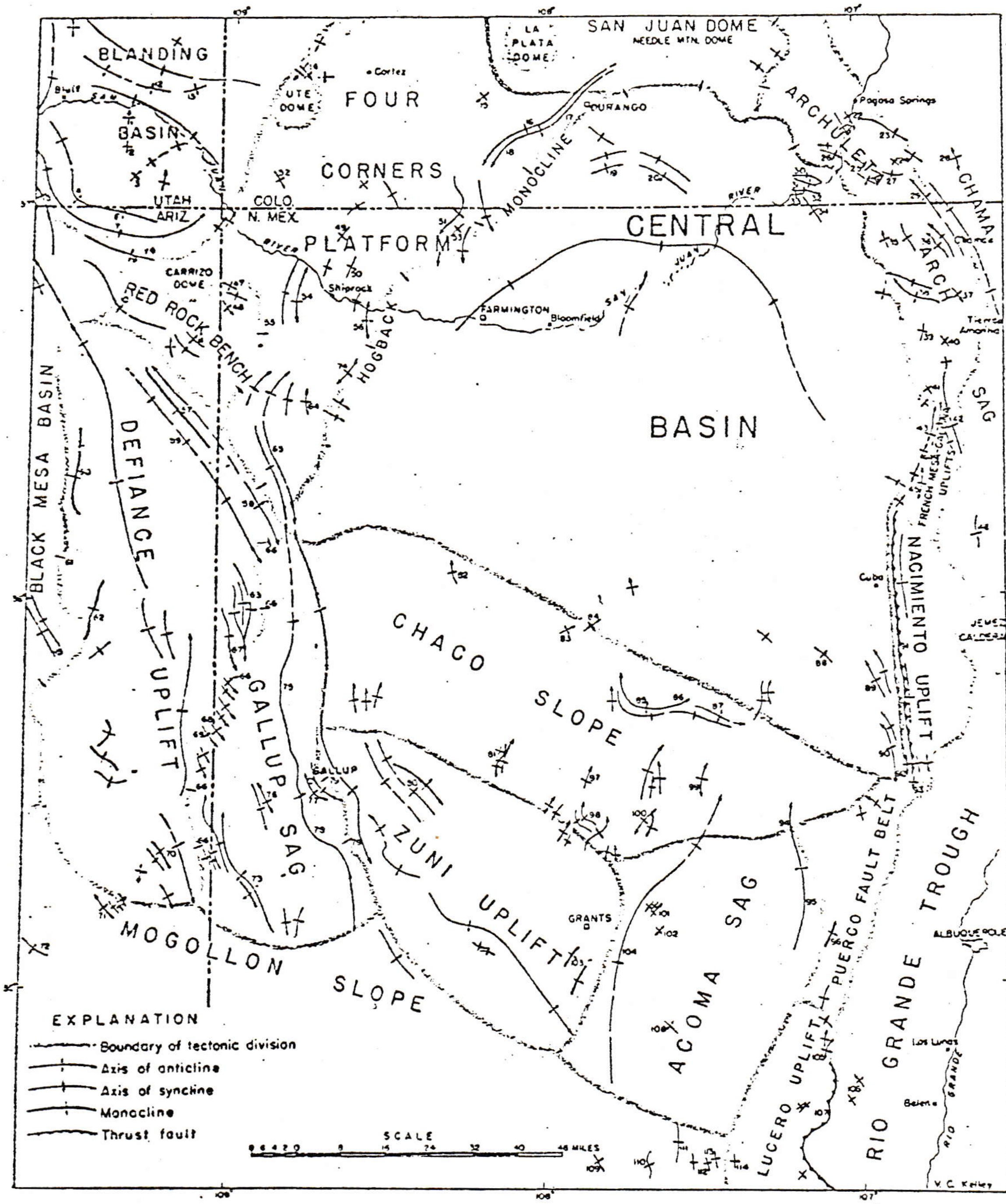

Figure 5. SAN JUAN BASIN AND ADJACENT AREAS

Source: Vincent C. Kelley, "Tectonic Setting," Geology and Technology of the Grants Uranium Region, Memoir 15, N.M. Bureau of Mines and Mineral Resources several units. A stratigraphic section in the important uranium producing area of Ambrosia Lake is shown in figure 6. In the Laguna district to the east of Ambrosia Lake a significant volume of uranium ore has been extracted from the Jackpile Sandstone (figure 7). A stratigraphic diagram of the Morrison Formation in the Grants region showing the relationship of its member between the Ambrosia Lake and North Laguna areas is given in figure 8.

Need for Dewatering of Conventional Underground Mines

The Morrison Formation outcrops along the southern edge of the San Juan Basin and then dips towards the central basin area. Historically uranium mining first occurred near the outcrop areas. Exploration has continued downdip in the Morrison with the newer mines in general being developed at ever increasing depth.

Except near the outcrop, the Morrison Formation is in most regions of the Basin one of the best water producing rock units in the state. Thus, in most of the deeper New Mexico uranium mines, dewatering of the orebody is necessary.

Dewatering Techniques and Sources of Water

To facilitate stoping (ore recovery) and to increase the strength of the rock, at least some drainage of the saturated orebody usually takes place before the uranium ore is recovered. The

4.017

Ambrosia Lake area, McKinley and Valencia Counties, New Mexico

AGE	GROUP	FORMATION	MEMBER	LITHOLOGY	THICKNESS (Feet)	CHARACTER
Upper Cretaceous	Mesa-verde	Point Lookout Sandstone	Main Body		60–160	Light gray and reddish-brown, medium- to fine-grained massive sandstone
			Satan Tongue (Mancos)		0–140	Dark gray sandy shale, some interbedded pale yellowish-brown, fined grained silty sandstone and siltstone
			Hosta Tongue		100–140	Light gray, medium- to fine-grained sandstone
		Crevass Canyon Formation	Gibson Coal Member		180–300	Light gray lenticular sandstone interbedded with gray siltstone, carbonaceous shale and coal
			Dalton Ss Member		60–150	Light gray, fine- to medium-grained sandstone
			Mulatto Tongue (Mancos)		220–400	Pale yellowish-brown, sandy shale, dark gray shale
			Borrego Pass Lentil		0–40	Gray, fine- medium- and coarse-grained sandstone
			Dilco Coal Member		80–180	Yellowish-gray, pale-orange sandstone, siltstone, carbonaceous shale, coal
		Gallup Sandstone	Main Body		0–120	Pale reddish-brown and light gray, fine- and medium-grained sandstone
			Pescado Tongue (Mancos)		140–160	Dark gray, silty shale
			Lower Part		10–40	Gray, fossiliferous, fine- and coarse-grained sandstone
		Mancos Shale	Main Body		600–650	Dark gray to black friable silty shale with minor light brown sandstone
			Twowells Ss Tongue (Dakota)		95–150	Yellowish-brown to buff, medium- to fine-grained sandstone
			Whitewater Arroyo Sh Tongue			Gray, black shale
		Dakota Sandstone	Paguate Ss Tongue		50–90	Gray, very fine-grained sandstone
			Clay Mesa Sh Tongue			Dark gray shale (Mancos)
			Cubero Ss			Gray, very fine-grained sandstone
Lower Cretaceous			Oak Canyon Member		85–160	Upper part—Light gray and grayish-tan, carbonaceous, very fine-grained sandstone and siltstone Lower part—Pale yellowish brown, orange, white, fine- and medium-grained sandstone
Upper Jurassic		Morrison Formation	Brushy Basin		40–220	Greenish-gray mudstone with minor lenticular, light gray and yellowish-gray, fine- and medium-grained sandstone
			Westwater Canyon		90–290	Light yellowish- and reddish-gray, medium grained sandstone, with greenish-gray, lenticular mudstone
			Recapture		70–250	Interbedded varigated mudstone claystone, siltstone and sandstone
	San Rafael	Bluff Sandstone			235–370	White, light gray, grayish-yellow, pale orange, and reddish-brown fine-grained, massive crossbedded sandstone
		Summerville Formation			160–270	Interbedded varigated mudstone and siltstone, fine- to very-fine-grained sandstone
		Todilto Limestone			25–35	Pale olive-gray, dark olive-gray, and pale yellow, thick-bedded limestone
		Entrada Sandstone	Upper Sandstone		150–185	Moderate brown, fine-grained, massive crossbedded sandstone
			Medial Siltstone		40–60	Grayish-red-brown calcareous siltstone
			Iyanbito		80–115	Moderate brown to moderate reddish-orange, medium-grained, crossbedded sandstone
Upper Triassic		Chinle Formation	Owl Rock		1100–1600	Greenish purple claystone and siltstone interbedded with pale blue to greenish-gray and pink limestone and silty limestone
			Correo Ss Petrified Forest (Upper)			Moderate grayish red to pale reddish-brown and purple mudstone, siltstone, and sandy siltstone
			Sonsela Ss Bed			White, light gray to yellowish-gray, and brown very-fine-grained to conglomerate sandstone interbedded with varicolored claystone
			Petrified Forest (Lower)			Blue to gray and reddish-purple mudstone and siltstone
			Monitor Butte			Grayish-red claystone and sandy siltstone, fine- to medium-grained sandstone, brownish-gray conglomerate
Permian		San Andres Limestone			95–115	Dense gray and yellowish-brown to red limestone with interbedded yellow, fine- to medium-grained, crossbedded sandstone, upper surface karst

Compiled by
W. L. Chenoweth
E. A. Learned
January 1979

SOURCE: DEPARTMENT OF ENERGY
GRAND JUNCTION OFFICE

FIGURE 7 -- Stratigraphic section, Laguna-Paguate Area, Valencia County, New Mexico

AGE	GROUP	FORMATION	MEMBER	LITHOLOGY	THICKNESS (Feet)	CHARACTER
Upper Cretaceous	Mesa-verde	Point Lookout Sandstone	Main Body		120	Grayish-orange to very pale orange, fine- to medium-grained sandstone
			Satan Tongue (Mancos)		50	Black to light-gray shale and siltstone
			Hosta Tongue		100	Pale-olive to very pale orange, fine- to medium-grained sanustone
		Crevass Canyon Formation	Gibson Coal Member		300	Interbedded yellowish-gray, fine-grained sandstone, dark gray shale and coal
			Dalton Ss Member		125	Upper sandstone moderate orange-pink to very pale orange, fine- to very fine-grained Lower sandstone grayish-orange to yellowish-gray, fine-grained Separated by gray siltstone
			Mulatto Tongue (Mancos)		350–400	Gray shale with some yellowish-gray, fine-grained sandstone
			Dilco Coal Member		85	Interbedded pale-orange to light brown sandstone and siltstone and grayish-brown shale
		Gallup Sandstone			80	Very pale orange to grayish-orange, fine-grained sandstone
		Mancos Shale	Main Body		750	Gray shale with some beds of yellowish-gray sandstone
			Twowells Ss Tongue (Dakota)		40–60	Grayish-orange to yellowish-gray, fine- to medium-grained sandstone
			Whitewater Arroyo Sh Tongue		80–100	Gray shale
		Dakota Sandstone	Paguate Ss Tongue		25-30	Grayish-orange to pale yellowish-brown, fine- to medium-grained sandstone
			Clay Mesa Sh Tongue (Mancos)		50	Gray shale
			Cubero Ss Tongue		20	Yellowish-gray to pale yellowish-brown, fine- to medium-grained sandstone
					20	Gray shale and siltstone, some thin limestone beds
Lower Cretaceous			Oak Canyon Member		10–80	Tan, orange, and white, fine- to medium-grained sandstone with some beds of black shale
Upper Jurassic		Morrison Formation	Jackpile Ss Bed		0–200	Yellowish-gray to white, fine- to coarse-grained sandstone with sparse thin beds of grayish-gray mudstone
			Brushy Basin		240–300	Grayish-green to light greenish-gray, sandy, bentonitic mudstone with thin beds of light gray, dense limestone, some interbedded grayish-yellow to very pale orange, fine- to coarse-grained sandstone
			Westwater Canyon		20-50	Grayish-yellow to very pale orange, fine- to coarse-grained sandstone
			Recapture		20-40	Grayish-red and greenish-gray mudstone, siltstone, and sandstone, sparse, thin beds of limestone
	San Rafael	Bluff Sandstone			300	Fine- to medium-grained sandstone. Grayish-yellow to very pale-orange alteration zone formed at the expense of pale reddish-brown sandstone
		Summerville Formation			90	Interbedded dark, reddish-brown to very light gray mudstone and moderate brown to very pale orange fine- to very fine-grained sandstone
		Todilto Limestone			10–80	Gray, fetid limestone 10–35 feet thick, overlain by massive gypsum 0–60 feet thick
		Entrada Sandstone	Upper Sandstone		80–120	Very fine- to medium-grained crossbedded sandstone, upper 10–30 feet, white to pale yellow; lower part pale red, light brown and moderate orange-pink
			Medial Siltstone		35–85	Light brown to pale reddish-brown siltstone; some fine- to very fine-grained sandstone
Upper Triassic		Chinle Formation	Correo Ss		1500±	Grayish-red to grayish-green shale with grayish-red to yellowish-gray fine- to coarse-grained sandstone and conglomerate in upper part, only upper 200 feet exposed

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March 1979

SOURCE: DEPARTMENT OF ENERGY
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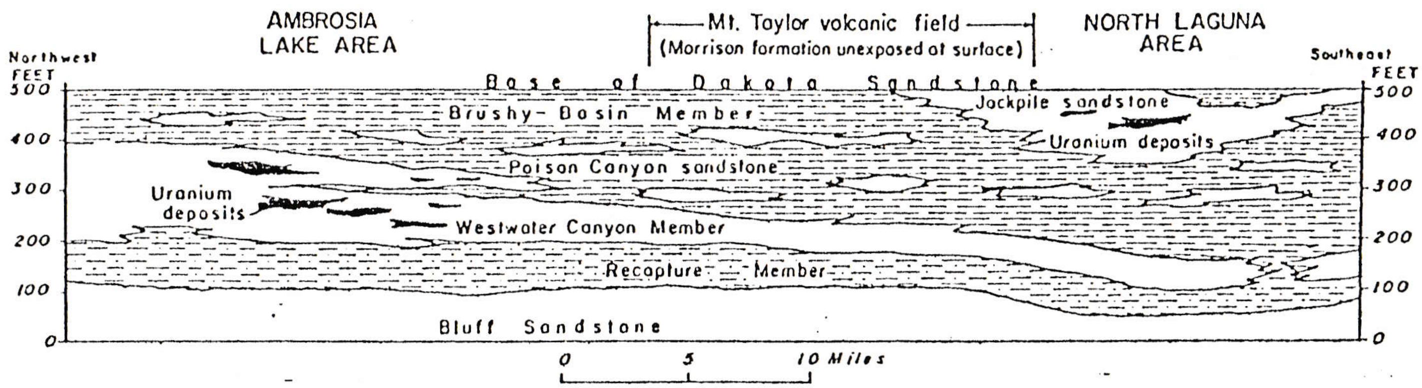
NEW MEXICO GEOLOGICAL SOCIETY—EIGHTEENTH FIELD CONFERENCE



Stratigraphic diagram of the Morrison Formation in the Grants region, showing the relationship of its members between the Ambrosia Lake and North Laguna areas.

Figure 8

Source: "Uranium Deposits of the Grants Region" by Kittel, Kelley and Melancon
New Mexico Geological Society - Eighteenth Field Conference Guidebook

drainage is accomplished by first constructing haulageways below the ore horizon along the probable long axis of the target ore body. Then long holes are drilled (usually from the ceiling of offsets along the haulage way) up into the ore body using pneumatic rotary drills. The holes are usually cased with perforated PVC pipe and the water from the ore body is drained into the haulageways. As the ore body is outlined, short haulages at right angles to the main haulage may be developed.

The drainage water is carried either by pipe or ditch down the haulageways to central sumps located at the shaft. In thick ore bodies with multiple level development, sumps may be located at more than one level of the mine. In many cases sumps are large enough so that some settling of suspended solids occurs before the water is pumped to the surface.

Residual water encountered during mining in the orebody is likewise drained to the sump area and pumped to the surface. Figure 9 illustrates a typical mine layout.

Infrequently while mining in the upper part of the Morrison Formation the back (roof) will break through into the Dakota Sandstone located above the Morrison. The Dakota in many areas is also an aquifer and unless remedial measures are taken to reduce inflow, water draining from the Dakota must also be collected at the sump and pumped to the surface.

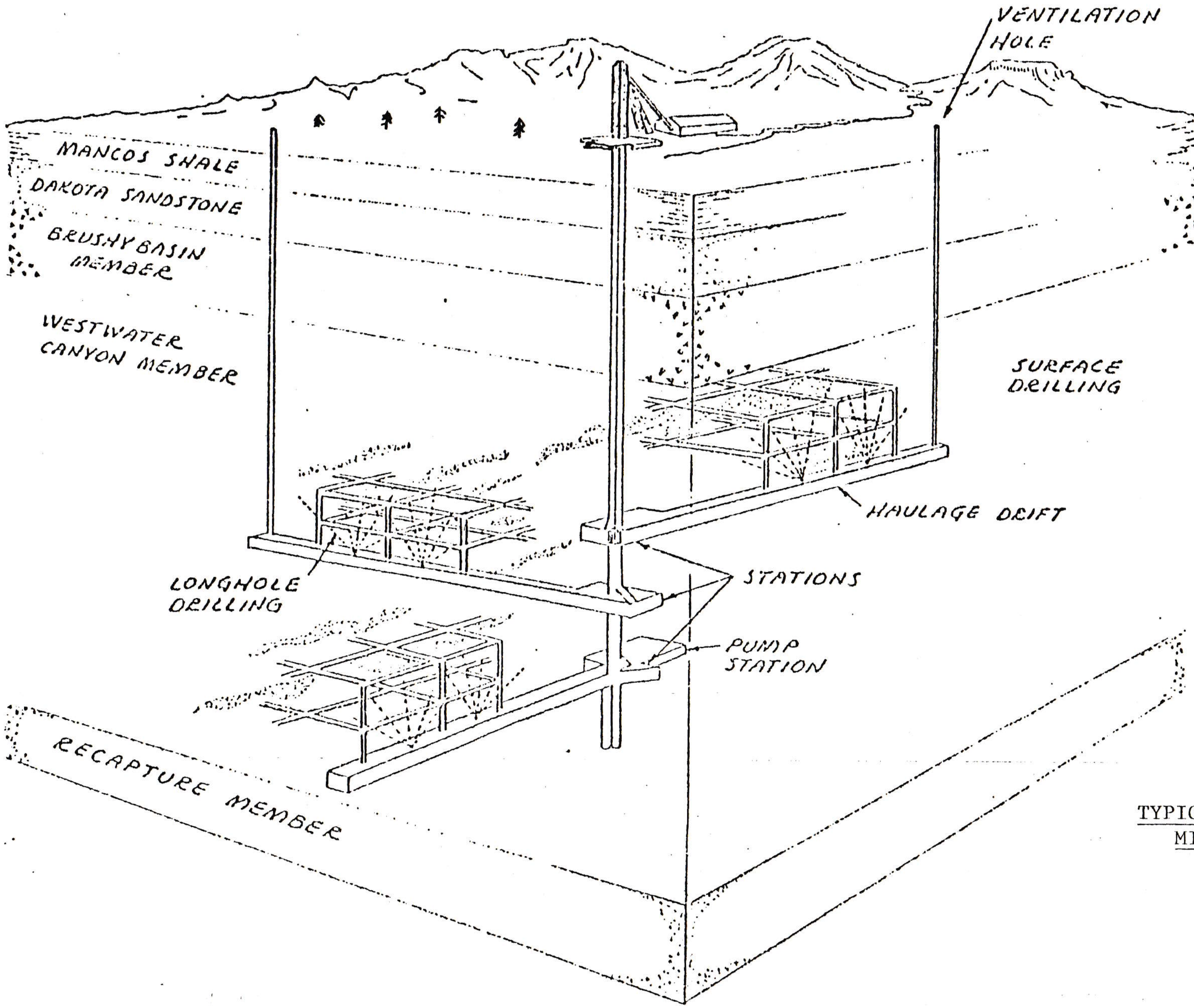


FIGURE 9

TYPICAL UNDERGROUND MINE LAYOUT

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SOURCE: Kerr-McGee Nuclear Corporation, Environmental Report, Rio Puerco Mine Project

Use of backfill is one technique which is being used extensively to prevent breakthrough into the Dakota and for ground control when pillars are pulled. Sands produced as waste from nearby uranium mills are often used as the backfill in the mines. Figure 10 illustrates a typical sand backfill operation. The area to be backfilled is bulkheaded by means of timbers with burlap stretched across. A slurry of sand-water is piped to the area and the section backfilled to the roof. The water quickly drains from the sand creating a stable fill. This drainage water is another source of fluid which must be removed from the mine. The slurry water removes some contaminants from the mill tailings sands and may have influence on the quality of the water ultimately pumped from a mine.

In some other mine areas, mine water recirculation may be used to extract additional uranium from formerly mined areas; particularly in those areas too dangerous to remove further ore from, or from areas where conventional mining is not economical. Water is either sprayed over oxidized low grade ore surfaces using "rainbird" type sprays, or holes are drilled from the surface of the ground to the top of the ore zone area and water is sprayed through these holes. The latter method is currently the most common, due at least in part to safety considerations. The water from the Morrison is slightly alkaline and leaches remaining oxidized uranium from the old stoping areas. The water is again collected in sumps in the mine and pumped to the surface. After uranium recovery in an ion exchange plant, the water may again be

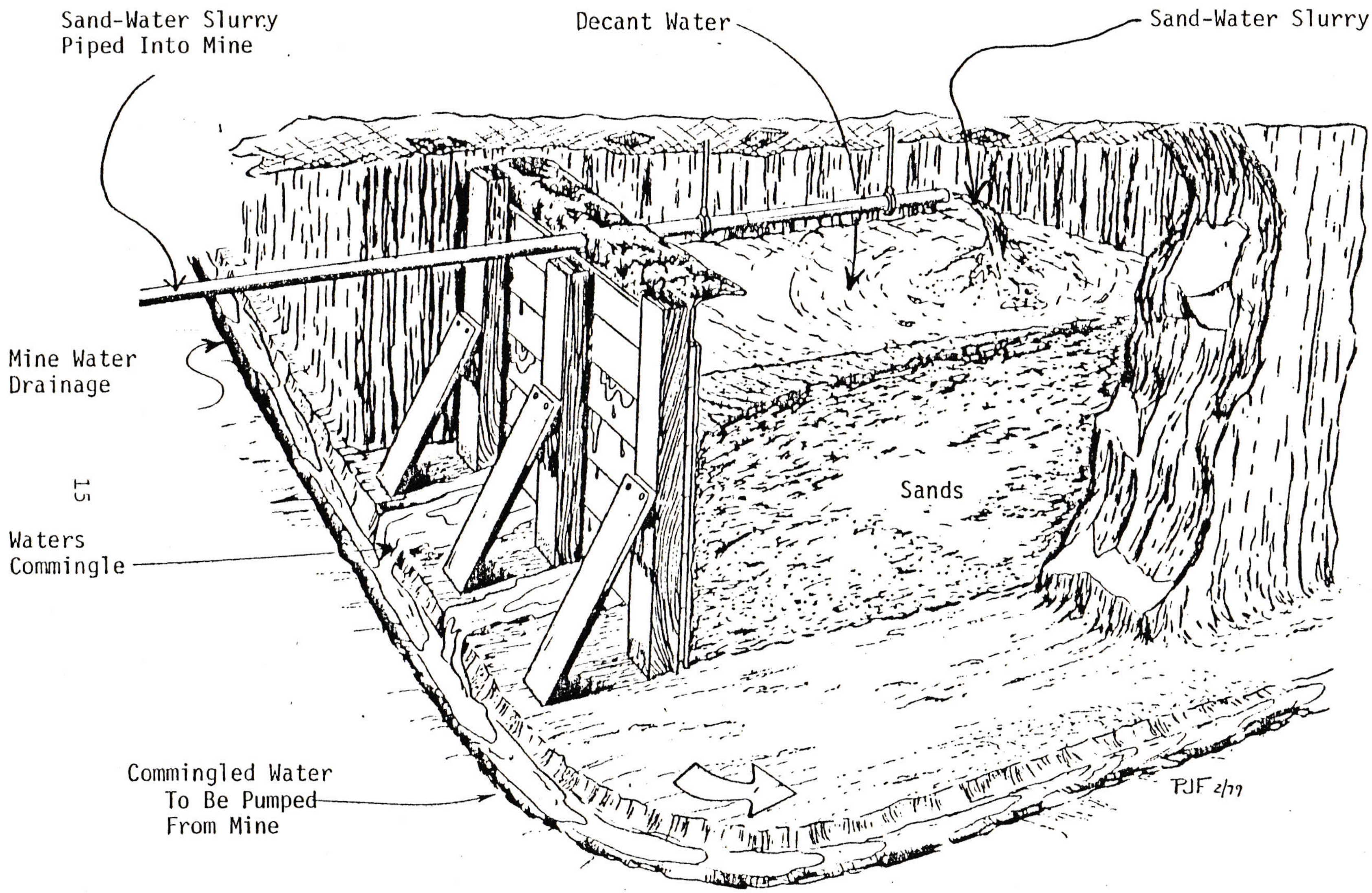


FIGURE 10 -- GENERALIZED DIAGRAM OF TAILINGS BACKFILL IN MINES

ADAPTED FROM UNITED NUCLEAR CORPORTION BACKFILLING DISCHARGE PLAN returned for further leaching. A mine may have most of its water flowing to the sumps coming from this type of reinjection or the mine may naturally make water and have a combination of reinjection water and aquifer inflow water. Mines do not undergo recirculation constantly as it is periodically necessary to discontinue mine face spraying for some period of time until further oxidation of the uranium can occur.

The mine sump is also used to collect water used in the drilling operations, in pump seals, etc. This water is also pumped to the surface.

Because of water drainage from sand backfill, mine water recirculation, mine use, etc. the amount of water from the mine pumped to the surface often exceeds the amount of water actually flowing from the aquifer into the mine. Every New Mexico mine is different and in order to evaluate the factors influencing water quality and flow each mine must be evaluated as an individual mining unit.

Dewatering is also often necessary during shaft sinking. Several aquifers may have to be transected before the ore producing formation is reached. In some of the deeper mines presently undergoing development, a ring of dewatering wells is drilled around the shaft site and completed into a water producing zone before shaft sinking reaches that zone. These wells are pumped to lessen pressure at the shaft as the shaft is being sunk through the water producing zone. Despite dewatering wells and extensive grouting in the region around the shaft, as the shaft is sunk through the different aquifers, water may seep into the shaft and must be pumped to the surface. Thus, during shaft sinking, water can be produced both from the shaft and from dewatering wells.

In some locations dewatering wells are not used. Any water produced during shaft sinking is therefore produced only from the shaft itself.

Water Treatment

Once the water pumped from a mine reaches the surface it usually goes through one or more mine water settling ponds. At most facilities a flocculant is added to promote settling. Barium chloride is usually added to the liquid after it has gone through one or more suspended solids settling ponds. Further settling and precipitation of radium as a barium sulfate salt then occurs as the liquid moves through additional settling pond(s). Where uranium levels are high enough to justify it, the liquid is usually run through an ion exhange (IX) plant for recovery of uranium contained in the mine water. The IX plant may either precede or follow barium chloride treatment. The water finally may be 1) discharged, 2) returned to the mine for drill water, mine water recirculation, etc., 3) used at nearby mills as process water, 4) used for irrigation, and/or 5) used on haul roads

TABLE I

WATER PRODUCTION - ACTIVE URANIUM MINES
NOVEMBER 1979

MINE	COMPANY	LOCATION	DEPTH (FT)	WATER INFLOW (gpm)
Section 22	Kerr-McGee	T14N R10W Section 22	827	
Section 33	Kerr-McGee	T14N R 9W Section 33	848	
Section 30	Kerr-McGee	T14N R 9W Section 30	750	
Section 24	Kerr-McGee	T14N R10W Section 24	837	2,500
Section 17	Kerr-McGee	T14N R 9W Section 17	1094	
Section 30W	Kerr-McGee	T14N R 9W Section 30	810	
Section 19	Kerr-McGee	T14N R 9W Section 19	779	
Section 35	Kerr-McGee	T14N R 9W Section 35	1398	1,600
Section 36	Kerr-McGee	T14N R 9W Section 36	1473	1,600
Church Rock #1	Kerr-McGee	T17N R16W Section 35	1851	3,800 (includes 1E)
Ann Lee	UNC	T14N R 9W Section 28	720	Small intermittent
Section 27	UNC	T14N R 9W Section 27	850	most recirculated
Sandstone	UNC	T14N R 9W Section 34	940	
Church Rock	UNC	T17N R16W Section 35	1800	1,200
St. Anthony (pit)	UNC	T11N R 4W Section 19 & 30	~ 150-200	20
St. Anthony (shaft)	UNC	T11N R 5W Section 24	320	20
Section 25	UN-HP	T14N R10W Section 25	811	
Section 23	UN-HP	T14N R10W Section 23	850	
Section 32	UN-HP	T14N R 9W Section 32	595	190
Section 15	UN-HP	T14N R10W Section 15	623	
Section 13	UN-HP	T14N R10W Section 13	618	
Johnny M.	Ranchers Exploration	T13N R 8W Section 7 & 18	1380	1,500
Hope	Ranchers Exploration	T13N R 9W Section 19	400	almost dry
Poison Canyon	Reserve Oil & Minerals	T13N R 9W Section 19	200 (below cliff)	dry
Section 12	Koppen	T14N R10W Section 12	665	dry
Section 14	Cobb	T14N R10W Section 14	384	dry
Westranch	Cobb	T15N R11W Section 32	320	dry
Ruby #1	Western Nuclear	T15N R13W Section 21	300-400	dry
Mariano Lake	Gulf	T15N R14W Section 12	519	190
JJ #1	Sohio	T11N R 5W Section 13	672	25
PW-2/3	Anaconda	T11N R 5W Section 33	adit	dry

TABLE I (cont'd)

WATER PRODUCTION - ACTIVE URANIUM MINES
NOVEMBER 1979

MINE	COMPANY	LOCATION	DEPTH (FT)	WATER INFLOW (gpm)
P-10	Anaconda	T10N R 5W Section 4	450	104
Jackpile-Paguate	Anaconda	T11N R 5W Section 33, 34, 35	150	almost dry
Jackpile-Paguate	Anaconda	T10N R 5W Section 2, 4, 5		
Haystack	Todilto Exploration & Development Corp.	T13N R10W Section 19, 18	150	dry
Haystack		T13N R11W Section 13		dry
Piedra Triste	Todilto Exploration & Development Corp.	T13N R 9W Section 30	160	dry
Isabella	Koppen	T13N R 9W Section 6	300	dry
Spencer Shaft #1		T13N R 9W Section 8		dry
Spencer Shaft #2		T13N R 9W Section 6		dry
Enos Johnson	Ray Williams	9 miles W Sanostee Boarding School	adit	dry
Section 21	M & M	T13N R 9W Section 21	decline	dry

for dust control. The end use and treatment vary from mine to mine and each mine must be studied individually if water use and treatment are to be understood.

Mine Water Inflow Rates

The rate at which a mine has water inflow from the aquifer depends on such factors as local conditions in the aquifer, stage of development of the mine, and mine size. Table I indicates the location, depth and large variation in inflow rates of present New Mexico mines in production, while Table II indicates location, depth, and November 1979 dewatering rates (including water from dewatering wells) at mines then undergoing development. The information in Tables I, and II was provided by company officials during the November 1979 sampling visit. Table III indicates historical water production for different mining areas in the San Juan Basin.

In Situ Leach Extraction

In contrast to conventional underground mining described above, in situ leaching is a process whereby uranium is extracted from underground ore bodies without use of excavations. Leaching solutions are pumped down injection wells into the underground ore body and drawn up from production wells. At the time of the EID sampling visits reported herein, there were no in situ operations in New Mexico which were injecting leaching chemicals. At the time of the 1979 visit, injection, production and monitoring wells had been installed at the Mobil Crownpoint Pilot Project, and baseline data were obtained by EID.

TABLE II

DEWATERING - URANIUM MINES UNDER DEVELOPMENT
NOVEMBER 1979*

MINE	COMPANY	LOCATION	TARGET DEPTH (FT)	WATER PRODUCTION (gpm)
Marquez	Bokum Resources	T13N R 5W Section 36	2100	1,034
Church Rock 1E[1]	Kerr-McGee	T17N R16W Section 36	1545	100 (pumped from #1 shaft)
Mt. Taylor	Gulf	T13N R 8W Section 24	3370	4,000
Rio Puerco[2]	Kerr-McGee	T12N R 3W Section 18	850	1,422
Nose Rock #1	Phillips	T19N R11W Section 31	3400	2,300
"	"	T19N R12W Section 36		
Old Church Rock[3]	UNC	T16N R16W Section 17	900	160 (intermittent)
Ruby 3 & 4	Western Nuclear	T15N R13W Section 26	360	dry
"	"	T15N R13W Section 25		dry
Section 10	Cobb	T14N R10W Section 10	NA	dry
Ruby #2	Western Nuclear	T15N R13W Section 27	360	dry

* Present Status (March 1980)

1) Completed
2) On Standby
3) In production

TABLE III

HISTORICAL APPROXIMATE* WATER PRODUCTION

FROM NEW MEXICO URANIUM MINING AREAS

Year	gpm Laguna	gpm Smith Lake	gpm Church Rock	gpm Ambrosia Lake	Total gpm	Gallons (million) Total Yr.
1956				500	500	262.8
1957				4,500	4,500	2,365.2
1958				8,500	8,500	4,467.6
1959				11,500	11,500	6,044.4
1960			400	11,500	11,900	6,254.6
1961		60	400	12,000	12,460	6,549.0
1962		85		11,600	11,685	6,141.6
1963		85		11,400	11,485	6,036.5
1964				11,300	11,300	5,939.3
1965				11,000	11,000	5,781.6
1966				9,500	9,500	4,993.2
1967			2,400	8,500	10,900	5,729.0
1968			2,300	8,300	10,600	5,571.4
1969			2,000	8,000	10,000	5,256.0
1970			3,500	8,500	12,000	6,307.2
1971			3,600	8,000	11,600	6,097.0
1972	30		4,000	8,000	12,030	6,323.0
1973	30		4,000	7,500	11,530	6,060.2
1974	100		4,000	7,000	11,100	5,834.2
1975	100		4,250	7,000	11,350	5,965.6
1976	150		4,250	7,400	11,800	6,202.1
1977	200	50	4,500	7,000	11,750	6,175.8
1978	225	200-300	5,400	7,420	13,345	7,014.1
				TOTAL WITHDRAWAL		127,371.4

1956-1978 Total = .39 million acre feet

* Does not include water produced during shaft sinking.

Source: Phillips Exhibit, Hearing before the State Engineer
July 31 - August 2, 1979

C. BACKGROUND INFORMATION ON URANIUM MILLS

Low concentrations of uranium are contained in N.M. ore (usually 1-8 pounds of uranium per ton of ore), and the ore must be processed in nearby mills to recover the uranium. New Mexico uranium mills, location, status, and type of circuit are listed in Table IV.

Once the uranium ore is received at a mill, it is ground and leached in order to place the uranium into a liquid solution. Then the uranium is extracted from the solution. The spent solution and other spent liquids are sent to a tailings disposal area along with the solid waste (which is the pulverized former uranium ore minus most of the uranium). Specific flow diagrams for N.M. mills vary from mill to mill. For these the reader is referred to the August 1974 issue of Mining Engineering and to the mill license applications on file with the New Mexico Environmental Improvement Division. Diagrams for a generalized acid and alkaline leach circuit are shown in figures 11 and 12.

As can be seen from the data presented later in this paper, the mill spent discharge liquor contains not only spent chemicals added during the leaching process, but also elements from the ore which are solubilized. Acid leach tends to solubilize different elements than the alkaline leach. The composition of the liquor is therefore dependent on 1) ore, 2) type of circuit, 3) any byproduct recovery, and 4) initial quality of process water.

TABLE IV

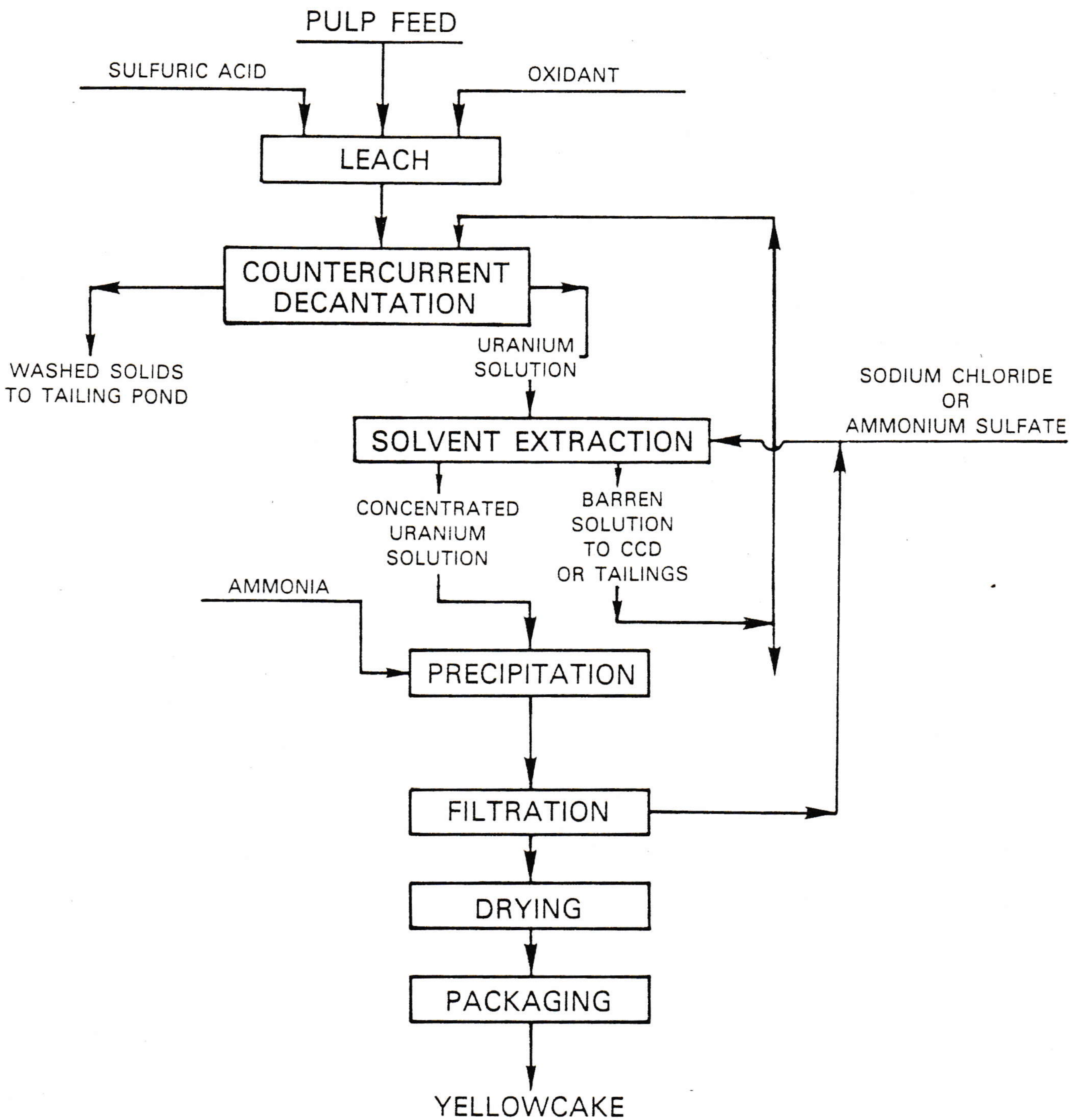
NEW MEXICO URANIUM MILLS (FEBRUARY 1980)

COMPANY	LOCATION	LICENSED CAPACITY ton/day	CIRCUIT	STATUS
Sohio Oil - Reserve Oil	Seboyeta (Cebolleta)	1660	acid	active
Kerr-McGee Nuclear	Ambrosia Lake	7000	acid	active
United Nuclear - Homestake Partners	Milan	3500	alkaline	active
Anaconda	Bluewater	6000	acid	active
United Nuclear	Church Rock	4000	acid	active - change of tailings operations will be necessary
Bokum Resources	Marquez	2200	acid	licensed - operations had not begun as of Feb. 1980
Gulf Mineral Resources	San Mateo	4200*	acid	license application under review
Phillips Uranium Co.	Nose Rock	2750*	acid	license application under review

* Capacity in License Application

FIGURE 11

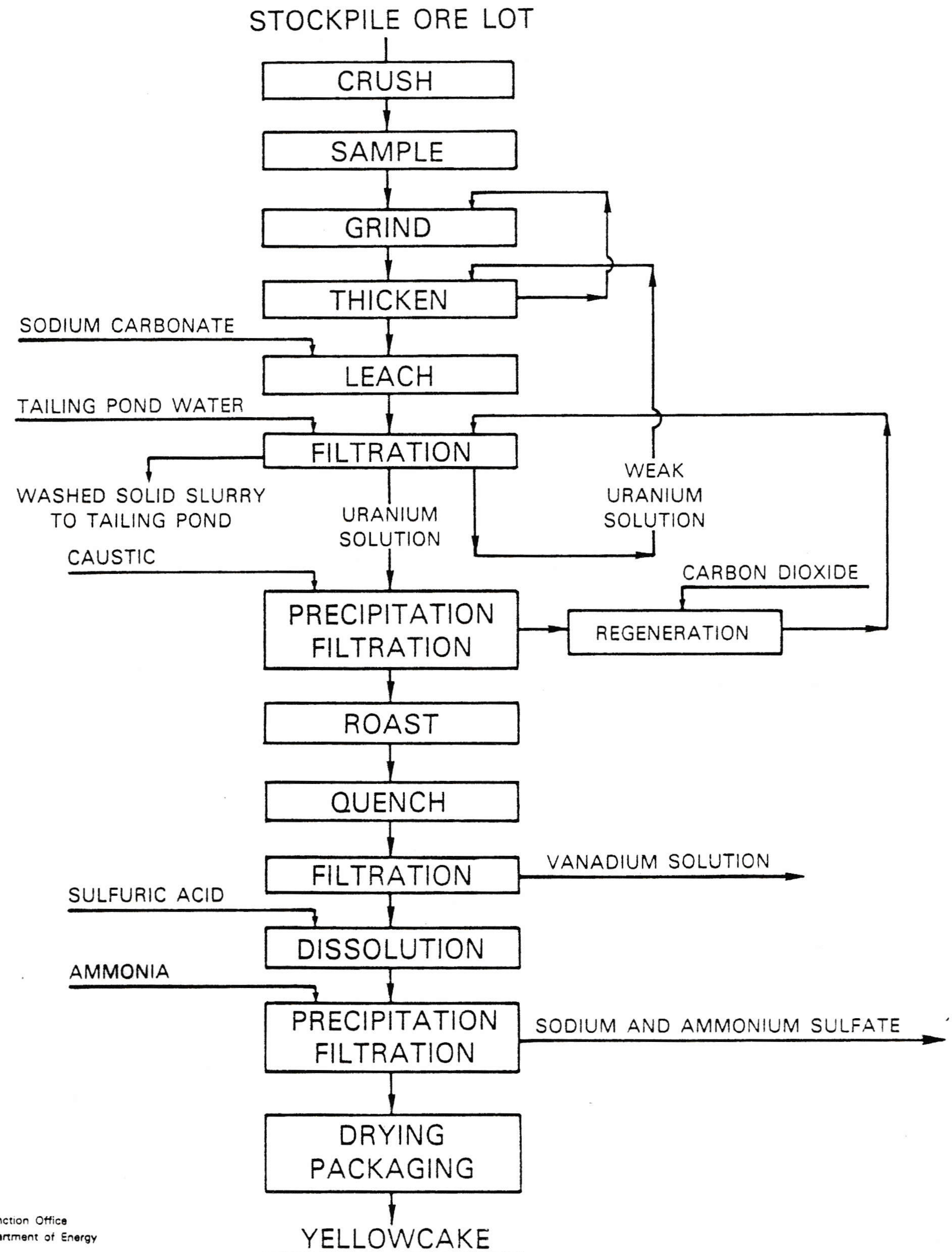
FLOWSHEET - ACID LEACH SOLVENT EXTRACTION (SX)



Grand Junction Office
U.S. Department of Energy

FIGURE 12

FLOWSHEET - ALKALINE LEACH, CAUSTIC PRECIPITATION



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For an acid mill approximately one and one half tons of water are required for every ton of ore processed. This water as it is discharged as spent liquor either evaporates in the mill tailings pond or decant ponds, is contained in the tailings as interstitial water, or is lost by seepage from the tailings disposal area. No New Mexico uranium mill has a intentional direct liquid discharge to a surface watercourse.

D. WATER QUALITY STANDARDS

In order that the reader can obtain some idea as to how the water quality of the discharges for which data is given compares to commonly used criteria, Table V lists the standards for ground water quality adopted by the New Mexico Water Quality Control Commission, and Table VI lists the "Effluent Limitations Guidelines for Existing Sources" used in issuing NPDES permits to uranium mining and milling facilities. All uranium facilities in New Mexico which have discharges to surface watercourses have had NPDES permits issued to them under the federal Clean Water Act. However, due to ongoing adjudication which had not yet been settled as of July, 1980, the permits have never been in effect for the following facilities: Bokum Resources Marquez Mine; Kerr-McGee Western and Central Ambrosia Lake Mines; Phillips Uranium Nose Rock Mines; Ranchers Johnny M Mine; and United Nuclear-Homestake Partners Ambrosia Lake Mines. In addition, the permit issued in 1974 to Kerr-McGee for its Church Rock I Mine has not been in effect due to adjudication, but that adjudication was settled May 15, 1980 and a permit will soon be in effect.

TABLE V

NEW MEXICO GROUND WATER STANDARDS

A - Standards for Human Health

Constituent	Symbol	Allowed Concentration
Arsenic	As	.1 mg/l
Barium	Ba	1.0 mg/l
Cadmium	Cd	.01 mg/l
Chromium	Cr	.05 mg/l
Cyanide	CN	.2 mg/l
Fluoride	F	1.6 mg/l
Lead	Pb	.05 mg/l
Mercury	Hg (total)	.002 mg/l
Nitrate (as Nitrogen)	NO_3 as N	10.0 mg/l
Selenium	Se	.05 mg/l
Silver	Ag	.05 mg/l
Uranium	U	5.0 mg/l
Radium	Ra-226 plus Ra-228	30.0 pCi/l

B - Other Standards for Domestic Water Supply

Constituent	Symbol	Allowed Concentration
Chloride	Cl	250 mg/l
Copper	Cu	1.0 mg/l
Iron	Fe	1.0 mg/l
Manganese	Mn	.2 mg/l
Phenols		.005 mg/l
Sulfate	SO_4	600 mg/l
Total Dissolved Solids	TDS	1000 mg/l
Zinc	Zn	10 mg/l
	pH	between 6 and 9

C - Standards for Irrigation

Constituent	Symbol	Allowed Concentration
Aluminum	Al	5 mg/l
Boron	B	.75 mg/l
Cobalt	Co	.05 mg/l
Molybdenum	Mo	1.0 mg/l
Nickel	Ni	.2 mg/l

TABLE VI - EFFLUENT LIMITATIONS GUIDELINES FOR EXISTING SOURCES
URANIUM, RADIUM AND VANADIUM ORES SUBCATEGORY

[6560-01]

Title 40—Protection of Environment

CHAPTER I—ENVIRONMENTAL PROTECTION AGENCY

SUBCHAPTER N—EFFLUENT GUIDELINES AND STANDARDS

[FRL 923-7]

PART 440—ORE MINING AND DRESSING POINT SOURCE CATEGORY

Effluent Limitations Guidelines for Existing Sources

AGENCY: Environmental Protection Agency.

ACTION: Final rule.

SUMMARY: This rule promulgates effluent limitation guidelines for existing facilities engaged in the mining and milling of base and precious metals, and iron, aluminum, ferroalloy, uranium, radium, vanadium, and mercury and titanium ores. The final regulation amends an interim final regulation which was promulgated on November 6, 1975 (40 FR 51722), and represents the degree of control achievable by the application of the best practicable control technology currently available (BPT). These guidelines are issued under the Federal Water Pollution Control Act and are intended to restrict the discharge of pollutants into the Nation's waters.

EFFECTIVE DATE: July 11, 1978.

Subpart E—Uranium, Radium and Vanadium Ores Subcategory

§ 440.50 Applicability; description of the uranium, radium and vanadium ores subcategory.

The provisions of this subpart are applicable to discharges from (a) mines, either open-pit or underground, from which uranium, radium and vanadium ore are produced; and (b) mills using the acid leach, alkaline leach, or combined acid and alkaline leach process for the extraction of uranium, radium and vanadium. Only vanadium by-product production from uranium ores is covered under this subpart.

§ 440.51 [Reserved]

§ 440.52 Effluent limitations guidelines representing the degree of effluent reduction attainable by the application of the best practicable control technology currently available.

(a) Subject to the provisions of Subpart H—General Provisions and Definitions, the following limitations establish the concentration of pollutants controlled by this section which may be discharged by a point source after application of the best practicable control technology currently available:

(1) The concentration of pollutants discharged in mine drainage from mines, either open-pit or underground, from which uranium, radium and vanadium ores are produced excluding mines using in-situ leach methods shall not exceed:

Effluent characteristic	Effluent limitations: Maximum for any 1 day	Effluent limitations: Average of daily values for 30 consecutive days shall not exceed—
	Milligrams per liter	
TSS	30	20
COD	200	100
Zn	1.0	0.5
Ra226* (dissolved)	10	3
Ra226* (total)	30	10
U	4	2
pH	Within the range 6.0 to 9.0	

*Values in picocuries per liter (pCi/l).

(2) The concentrations of pollutants discharged from mills using the acid leach, alkaline leach or combined acid and alkaline leach process for the extraction of uranium, radium and vanadium including mill-mine facilities and mines using in-situ leach methods shall not exceed:

Effluent characteristic	Effluent limitations: Maximum for any 1 day	Effluent limitations: Average of daily values for 30 consecutive days shall not exceed—
	Milligrams per liter	
TSS	30	20
COD	....	500
As	1.0	.5
Zn	1.0	.5
Ra226*(dissolved)	10	3
Ra226*(total)	30	10
NH3	....	100
pH	Within the range 6.0 to 9.0	

*Values in picocuries per liter (pCi/l).

II. DATA COLLECTION

A. SAMPLE COLLECTION AND PRESERVATION

In the fall of 1977, 1978, and 1979 every accessible uranium mine undergoing dewatering and every active uranium mill was visited and samples were collected. The location of each sample collection point will be indicated in discussion of the data. At each sampling location, samples were collected into at least three new polyethylene quart bottles and one new polyethylene gallon bottle. Each bottle and lid was carefully rinsed with the liquid to be sampled before the container was filled. At the time of sampling, date of sampling, location of sampling point, liquid temperature, and electrical conductivity was recorded on each set of bottles.

Except as will be noted for one set of baseline samples, none of the liquids was filtered. To stabilize the samples, 20 ml of nitric acid was added to the gallon bottle for gross alpha and radium-226 analyses. One of the quart bottles had 2 ml of sulfuric acid added, and this sample was used for nitrate plus nitrite and ammonia analyses. Another quart bottle had 5 ml of nitric acid added for the samples analyzed for total arsenic, barium, cadmium, lead, molybdenum, selenium, uranium, vanadium, zinc and aluminum. Finally, the sample in the untreated quart bottle was analyzed for chloride, potassium, magnesium, bicarbonate, calcium, sodium, and sulfate. In addition conductivity, pH, total nonfilterable residue (suspended solids) and total filterable residue (dissolved solids) were obtained from the untreated quart sample. These procedures were all in accordance with Standard Methods for the Examination of Water and Wastewater, latest edition, American Public Health Association, and Methods for Chemical Analysis of Water and Wastes, Analytical Quality Laboratory, EPA.

B. SAMPLE ANALYSIS

The samples were analyzed by the New Mexico Scientific Laboratory Division (SLD) of the Health and Environmental Department located in Albuquerque, New Mexico except for the 1978 and 1979 gross alpha and radium analyses which were done by Eberline Laboratory in Albuquerque. Table VII and Table VIII indicate the techniques used.

Table VII

ANALYTICAL TECHNIQUES USED BY STATE LABORATORY (SLD)

Data	Technique
TSS	gravimetric (used filter minus new filter)
TDS	evaporation plus gravimetric
cond	cond. meter plus temperature correction
pH	pH meter
As	atomic absorption spectrophotometric (AA) with nickel-nitrate addition
Ba	AA
Se	AA with nickel-nitrate addition
Mo	AA
NH_3-N	colorimetric-Technicon Autoanalyzer
Na	flame emission spectrophotometric
Cl	colorimetric-Technicon Autoanalyzer
SO_4	colorimetric-Technicon Autoanalyzer
Ca	EDTA titration
K	flame emission spectrophotometric
HCO_3/CO_3	potentiometric titration
Cd	AA
NO_3/NO_2-N	colorimetric-Technicon Autoanalyzer (cadmium reduction)
Mg	EDTA titration
Pb	AA
V	AA
Zn	AA
Al	AA
U	fluorescence, sodium fusion

Table VIII

ANALYTICAL TECHNIQUES USED BY EBERLINE

Data	Technique
Ra-226	radon emanation
gross-alpha	evaporation and alpha count with correction for absorption

III. DATA PRESENTATION

A brief descriptive narrative will accompany each set of data. Most information in the narrative, including the construction status of facilities and whether or not they were in operation, is based on observations by EID personnel during each sampling visit, and some is from EID and Energy and Minerals Department files. Specific information on quantities of barium chloride being added, water discharge rates, shaft depths, backfilling status, and mine water recirculation status, was obtained verbally from company officials. Data will be given by mining area for the following:

A. Active mines (those producing uranium ore in commercial quantities) undergoing dewatering. After water treatment many of these facilities have a final surface discharge to a watercourse. In addition to samples of the final discharge, some untreated raw mine water samples and samples from final settling ponds will be included.

B. Mines under development discharging water from development activites, each of which has a surface discharge to a watercourse. Data for samples of the discharge effluent collected each year and in some cases (1979) the untreated water will be given.

C. Base line ground water samples. Data on ground water quality obtained from samples collected from wells completed into the ore zone at areas not undergoing development or mining at the time of sampling will be included.

D. Mills. Liquid samples were taken either from the tailings pond itself, from sumps collecting tailings water, or from tailings liquor decant ponds. No New Mexico mill has an intentional surface discharge to a watercourse.

A. ACTIVE MINES

Church Rock Area (See Figure 2)

Kerr-McGee Corporation Church Rock I & I East Mines

At the Kerr-McGee Church Rock mine there are two shafts of which IE (I East) has just recently been completed. The two shafts are connected underground, and water produced from IE flows to a central sump located in the original shaft for pumping to the surface. Production from the Westwater Canyon Member of the Morrison Formation began in 1977. In 1977 water inflow was approximately 3200 gpm, in 1978 3750 gpm, and in 1979 3800 gpm. The water, pumped from the mine at approximately 28°C, first has a flocculant added as it enters the first of several settling ponds (four in 1977, three in 1979). Before the water enters the second to last pond barium chloride is added for radium precipitation. In 1977 approximately 25 mg of $BaCl_2$ per liter of mine water was added, while in 1979 approximately 21 mg of $BaCl_2$ per liter was added. After the $BaCl_2$ addition the water is calculated to be retained for approximately 70 hours before discharge into Pipeline Arroyo (a tributary of the Rio Puerco of the West).

Table IX lists the data for samples obtained at this mine. Data labeled "outfall" were collected just as the water entered the outfall pipe to the arroyo. Data labeled "raw mine water" were collected at the point where water pumped from the mine was discharged to the first pond.

The mine is not undergoing backfill or mine water recirculation at the present time, and has not in the past.

United Nuclear Corporation Northeast Church Rock Mine

The United Nuclear NE Church Rock mine has been producing from host rock in the Westwater Canyon Member through two shafts since 1969. There are sumps at two levels in the mine. Inflow in 1977 was approximately 1300 gpm, in 1978 approximately 1250 gpm, and in 1979 approximately 1200 gpm. The discharge water first has a flocculant added with the water as it enters the first of several initial settling ponds. UNC reports that approximately 450-800 pounds per day (52-55 mg $BaCl_2$/liter water) of barium chloride is added before the water enters the final set of settling ponds. During the 1979 visit UNC reported that acid was being added as the water entered one of the ponds in order to lower the pH of the mine water from a mine discharge value of 9-9.5.

After the settling ponds the water is sent to a central sump. The water is then pumped to an ion exchange facility where uranium is recovered in two four foot resin beds in series and

Table IX

Kerr McGee Church Rock I and IE Mine

	10/24/77 Outfall	11/13/78 Outfall	11/01/79 Outfall	11/01/79 Raw Mine Water
TSS mg/l	25.4	< 1.0	2.0	
TDS mg/l	363	412	391	
cond µmhos	589	776	681	
pH	8.59	NA	8.58	
As mg/l	< .005	.009*	.022	
Ba mg/l	2.13	.28*	.435	
Se mg/l	.03	.021*	.040	
Mo mg/l	< .01	.463*	.612	
NH_3 mg/l	.024	.07	.05	
Na mg/l	121.9	133.4	121.9	
Cl mg/l	9.3	26.3	12.0	
SO_4 mg/l	60.6	126.8	120.5	
Ca mg/l		15.2	16.8	
K mg/l		9.75	1.17	
Ra-226 pCi/l	89±5	2±.2	1.3±.4	250±80
Ra-228 pCi/l	0±2			
U mg/l	1.0	.165*	1.140	
Po-210 pCi/l	15±5			
gross α pCi/l		400±40	1200±100	1100±100
bicarbonate mg/l		220.1	240.7	
Cd mg/l		.0015*	.001	
Pb mg/l		.005*	.005	
nitrate + nitrite mg/l		.34	.17	
V mg/l		.01*	.010	
Zn mg/l		.005*	.250	
Al mg/l			.250	
Mg mg/l			7.7	

* Not acidified

further radium is removed in another four foot bed. The uranium is stripped from the resin with an ammonium sulfate solution. Pregnant solution is piped to the nearby mill for uranium recovery. UNC states that spent resin from the radium removal circuit will be disposed of in the tailings pile or a similarly suitable area.

Most of the treated mine water is used as process water in the nearby UNC Church Rock uranium mill. Excess water is discharged into Pipeline Arroyo, a tributary of the Rio Puerco of the West.

In early 1979 UNC began backfilling with tailings sands at their mine, with use of only selected coarse sands recently being required by the State. Backfilling was underway at this mine during the EID visit of 11/01/79. During a subsequent EID visit on 3/5/80, backfilling was not taking place and had not taken place since 2/29/80. Samples taken on 3/5/80 were analyzed for all parameters at the New Mexico Scientific Laboratory Division. There have been no reported mine water recirculation operations at this mine.

Data for samples collected at the point of water discharge into the arroyo (outfall) are shown in Table X, as well as one set of data for a sample collected at Pond #2, one of the initial settling ponds.

Table X

United Nuclear Northeast Church Rock Mine

		10/24/77 Outfall No Back-filling	11/13/78 Outfall No Back-filling	11/01/79 Outfall Backfilling Underway	03/05/80 Outfall No Back-filling	03/05/80 Pond #2 No Back-filling
TSS	mg/l	NA	4.2	0	4.5	11.1
TDS	mg/l	383	419	587	453.	441
cond	µmhos	681	623	923	725.	702
pH		8.82		7.66		
As	mg/l	<.005	<.005	<.005	<.005	<.005
Ba	mg/l	.88	.381	.707	.311	.201
Se	mg/l	.094	.074	.053	.082	.082
Mo	mg/l	< .01	.065	<.010	.01	.009
NH_3	mg/l	.036	.19	1.25		
Na	mg/l	144.9	149.5	144.9	147.2	149.5
Cl	mg/l	24.2	25.4	20.4	26.2	12.2
SO_4	mg/l	67.2	107.6	361.5	126.1	108.6
Ca	mg/l		8.0	27.6	13.4	10.0
K	mg/l		1.56	1.56	1.56	1.56
bicarbonate	mg/l		229.6	32.6	256.	258.2
Cd	mg/l		<.001	<.001	<.001	<.001
Pb	mg/l		<.005	<.005	<.005	<.005
nitrate + nitrite	mg/l		.46	.34		
V	mg/l		.030	<.010	.024	< .01
Zn	mg/l		< .001	<.250	<.250	<.250
Al	mg/l			<.250		
Ra-226	pCi/l	1.9±.8	2.0±.1	.81±.24	3.89±0.15	38.9±1.3
Ra-228	pCi/l	0±2				
Po-210	pCi/l	9.7±5.6				
U	mg/l	1.2	1.32	1.26	.516	3.26
gross α	pCi/l		900±60	650±80	282±18	1890±100

United Nuclear Corporation Old Church Rock Mine

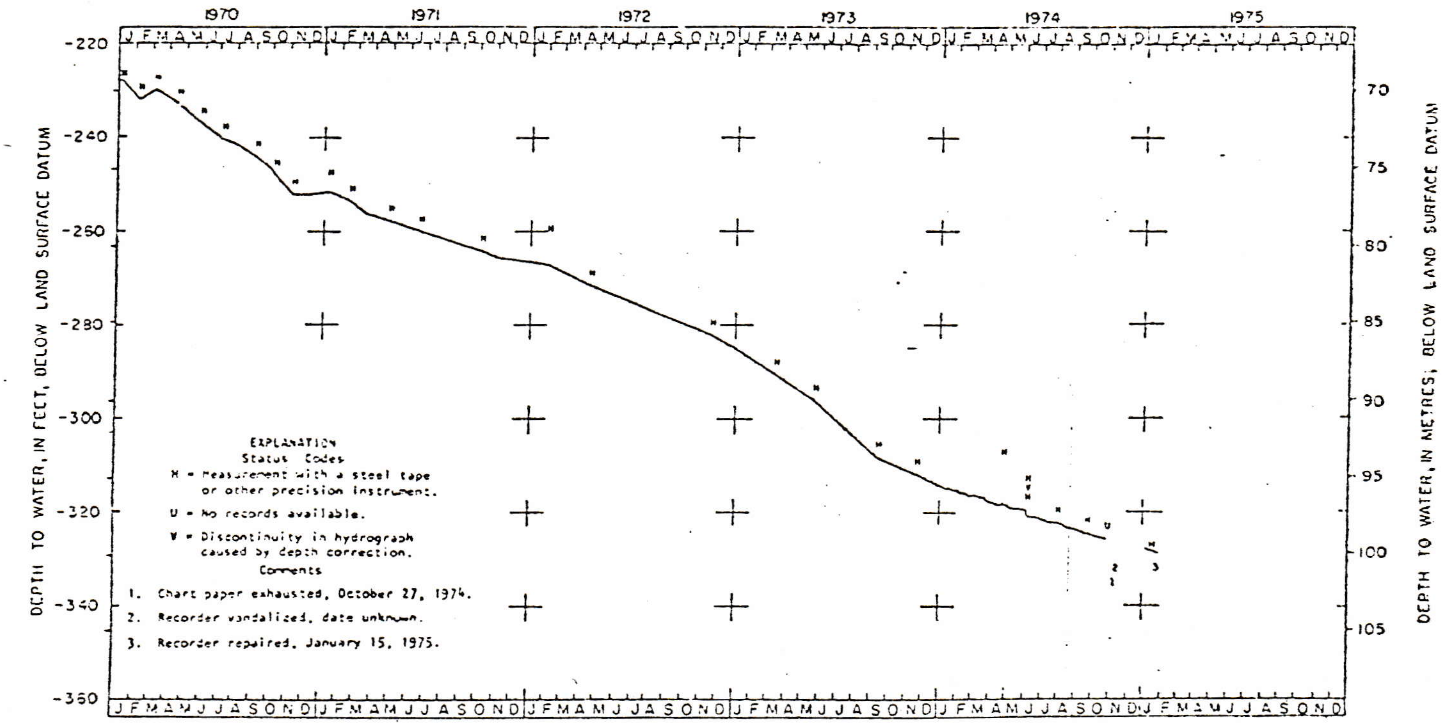
The Old Church Rock mine was first mined from 1960 until 1962 (Lowell Hilpert, Geological Survey Professional Paper 603). The host rock includes the Westwater Canyon Member of the Morrison Formation. It was reentered by United Nuclear in 1979. Because the 900 feet deep mine was completely flooded (depth to water in the shaft was approximately 400 feet), it was necessary to de-water the mine. Water levels in the mine have historically declined since UNC's Northeast Church Rock mine has been in operation (figure 13). The inflow of water has been less than expected. At the time of the 1979 sampling the initial water filling the mine had been removed, and approximately 160 gpm was being pumped from the mine sump on an irregular basis.

The water is placed in a series of settling ponds. No barium chloride treatment is used. An ion exchange facility has been located at the mine; however because of the low water inflow rate it is rarely used. At the time of the November 1979 visit there was no water being discharged from the ponds and the water sample was obtained from the last pond. When there is a surface discharge it will be to Pipeline Arroyo, tributary of the Rio Puerco of the West.

The data obtained from the pond sample are given in Table XI.

Figure 13 - Water Levels in United Nuclear Corporation's Old Church Rock Mine

URANIUM MINE WASTE WATER



The water level observed in the shaft of the abandoned United Nuclear Corporation's Northeast Church Rock mine, SE¼ NW¼ NE¼ sec. 17, T. 16 N., R. 16 W., McKinley County, New Mexico. [Water level prior to start of dewatering in October 1968 during sinking of new uranium mine shaft in sec. 35, T. 17 N., R. 16 W. reported to be 144 ft (44 m). Water level measured from land surface datum estimated from a topographic map to be 6,810 ft (2,076 m).]

Source: "Uranium Mine Waste Water - A Potential Source of Ground Water in Nothwestern New Mexico" by William L. Hiss

Table XI

United Nuclear Old Church Rock Mine

(last settling pond)

	11/01/79
TSS mg/l	175
TDS mg/l	899
cond μmhos	1589
pH	8.66
As mg/l	< .005
Ba mg/l	.940
Se mg/l	.029
Mo mg/l	< .010
NH_3 mg/l	.07
Na mg/l	315.1
Cl mg/l	19.4
SO_4 mg/l	434.7
Ca mg/l	20.0
K mg/l	1.95
bicarbonate mg/l	372.1
Cd mg/l	< .001
nitrate + nitrite mg/l	.02
Mg mg/l	4.5
V mg/l	.095
Zn mg/l	< .250
Al mg/l	5.17
Pb mg/l	< .005
gross α pCi/l	5300±300
Ra-226 pCi/l	4.2±1.3
U mg/l	11.4

Smith Lake Area (See Figure 2)

Gulf Mineral Resources Corporation Mariano Lake Mine

Presently the only mine in active production in the Smith Lake area which requires dewatering is Gulf's Mariano Lake mine. Dewatering rates at this mine increased from 47-58 gpm in 1977 (when the mine was beginning its production which is from the Poison Canyon Sandstone) to 250 gpm in 1978, and then decreased to approximately 200 gpm in 1979.

The water, pumped from the mine at 13°C, is first discharged to a small, double settling pond (one section can be cleaned while the other is in use). The water then flows through three 20 mil PVC lined lagoons (two of 450 ft x 400 ft x 5 ft each and one of 400 ft x 500 ft x 5 ft).

In 1977 there was no discharge to a watercourse and in 1978 and 1979 discharges to a watercourse were irregular and were not taking place during the EID visit. Each year a water sample was taken from the last lagoon. The raw mine water was collected at the initial sump area. All data are shown in Table XII.

In 1978 a barium chloride treatment system was installed between the lagoons. Treatment in 1979 consisted of 35 mg of $BaCl_2$ added per liter of mine water.

Table XII

Gulf Mariano Lake Mine

	10/25/77	11/15/78	11/05/79+	11/05/79[1]
	Settling Pond	Setting Pond	Settling Pond	Raw Mine Water
TSS mg/l	NA	2.9	2.0	161
TDS mg/l	1643	1071	1238	1167
cond μmhos	1964	1432	1534	1416
pH	7.77		7.87	7.10
As mg/l	< .005	<.005	<.005	NA
Ba mg/l	NA	.183	.172	NA
Se mg/l	.002	.047	.015	NA
Mo mg/l	.05	.913	.480	NA
NH_3 mg/l	.032	.10	.15	.16
Na mg/l	48.3	25.3	27.6	18.4
Cl mg/l	53.5	119.1	97	21.6
SO_4 mg/l	1045.0	564.3	659.5	683.0
Ca mg/l		203.0	221.6	112.0
K mg/l		4.29	4.68	5.46
bicarbonate mg/l		85.4	77.2	139.5
Cd mg/l		.005	< .001	NA
nitrate + nitrite		.02	< .01	.23
Mg mg/l			62.3	122.9
V mg/l		< .010	< .010	NA
Zn mg/l		< .1	< .250	NA
Al mg/l			< .250	NA
Pb mg/l		< .005	< .005	NA
gross α pCi/l		1000±100	800±100	1100±100
Ra-226 pCi/l	.1±.1	.14±.08	.10±.03	34±10
Ra-228 pCi/l	0±2			
Pb-210 pCi/l	0±2			
U mg/l	.18	2.64	1.51	5-6[2]

\+ Included IX + Ba treatment

1 Water discharge directly from the mine

2 Company data

In 1979 an ion exchange facility for uranium recovery began operation. According to Gulf uranium concentration at the inlet to the IX averages 5-6 mg/l. The IX utilizes a pressure system. The uranium is stripped from the resin using sodium chloride and the pregnant solution is sent to Kerr-McGee's mill at Ambrosia Lake. The precipitated radium containing sludge will go to some mill's tailings pile when the mine closes (probably 1981-1982).

The later water data may show some influence of the overlying Dakota as a small breakthrough into the Dakota may have occurred during pillar robbing.

There had been no backfilling and no mine water recirculation in this mine when the samples were taken. When there is a surface discharge from the ponds, it enters an unnamed arroyo which is tributary to the Rio Puerco of the West.

Ambrosia Lake Area (See Figure 3)

Specific determination of water quality at each separate mine in the western and central sections of the Ambrosia Lake area is in some cases not possible because of the intermingling of several mine discharges together. Sampling was therefore conducted at each treatment facility.

United Nuclear - Homestake Partners Mines

Water quality of the discharge into the Arroyo del Puerto from the ion exchange plant operated by United-Nuclear Homestake Partners as well as quality of the water entering the IX plant, is shown in Table XIII. The water initially is pumped from some UN-HP western Ambrosia Lake mines. At each mine the water is discharged into a settling pond at the mine site. Decant from these ponds then goes to recently constructed holding ponds located near the ion exchange facility.

The water from the holding ponds, containing approximately 20-30 mg/l of uranium, enters the ion exchange plant where the uranium is removed in resin beds. Sodium chloride is used to strip the resin when it becomes loaded. The pregnant solution is sent to the UN-HP mill at Milan for recovery of the uranium.

In 1979, 1800-1900 gpm was being run through the IX facility. Approximately 1600 gpm was then sent back to some of the mines and sprayed into previously mined areas in order that the water could leach uranium remaining in these areas. Since the mines were also having some net inflow of water from the Westwater Member of the Morrison Formation (which is the host rock for the uranium) it was necessary to discharge approximately 190 gpm into the arroyo. The rest of the inflow water is lost through evaporation etc.

Table XIII

United Nuclear - Homestake Partners IX

	10/26/77 In Arroyo	11/16/78 Outfall to. arroyo	11/06/79 Outfall to arroyo	11/06/79+ IX Feed
TSS mg/l	< 1	13.4	6	6
TDS mg/l	1324	1689	1695	1799
cond μmhos	1906	2456	2296	2153
pH	8.14		7.25	6.45
As mg/l	.011	.202	.026	.026
Ba mg/l	.17	.152	.173	.182
Se mg/l	.407	.583	1.047	1.222
Mo mg/l	.45	.286	1.331	1.331
NH_3 (total) mg/l	.11	.07	.57	.07
Na mg/l	207	250.7	243.8	230.0
Cl mg/l	70.5	490.2	148.8	101.2
SO_4 mg/l	675.0	450.7	921.6	948.7
Ca mg/l		178.4	76.8	86.2
K mg/l		11.7	12.1	12.09
bicarbonate mg/l		180.8	140.5	160.4
Cd mg/l		<.001	<.001	<.001
nitrate + nitrite		2.29	2.09	3.00
Mg mg/l			106	127.9
V mg/l		.160	.185	.260
Zn mg/l		.220	<.250	<.250
Al mg/l			<.250	<.250
Pb mg/l		.009	<.005	<.005
gross α pCi/l		950±90	210±30	1900±100
Ra-226 pCi/l	4.7±1.2	9.4±.2	2.5±.8	130±40
Ra-228 pCi/l	0±2			
Pb-210 pCi/l	16±7			
U mg/l	1.9	2.95	2.42	20.0

\+ Received from mines

Before discharge to the arroyo the water from the IX is treated with $BaCl_2$ and undergoes settling in order to remove Ra-226. In 1977 $BaCl_2$ was being added as a "pilot" operation. By 1979 10 to 15 mg of $BaCl_2$ and 3 to 4 mg of flocculant (to promote settling) was added per liter of discharge water.

Samples of the final discharge to the arroyo were taken in the arroyo in 1977, and at the point of discharge to the arroyo in 1978 and 1979. The last column of Table XIII indicates data for the sample taken at the IX feed where the water was coming from the holding pond before the water entered the IX.

Company officials have indicated that about 15 years ago small amounts of blowsand ware backfilled into Section 23 & 25 mines. In addition there has been limited use of barren mine waste which has been pushed into mined out areas.

Kerr-McGee Corporation Western and Central Ambrosia Lake Mines

In the western and central sections of Ambrosia Lake, according to company officials water is pumped from Kerr-McGee's Section 22, 33, 24, 17, 19, 30 and 30W mines (which have their host rock in the Westwater Canyon member), into settling ponds at the individual mines. Part of the decant water from the mine settling ponds (approximately 500 gpm) is recirculated to the Section 17, 22 and 33 mines to leach additional uranium which has been oxidized and hence rendered generally soluble. The rest of the de-

Table XIV

Kerr-McGee Western and Central Ambrosia Lake Mines

(IX at Mill)

		10/26/77 Outfall	11/16/78 Outfall
TSS	mg/1	2.2	< 1.0
TDS	mg/1	1606	1702
cond	μmhos	2195	2310
pH		8.0	
As	mg/1	.012	.007
Ba	mg/1	.66	.113
Se	mg/1	.036	.106
Mo	mg/1	.79	.896
NH_3	mg/1	.014	.03
Na	mg/1	271.4	273.7
Cl	mg/1	88.1	91.0
SO4	mg/1	837.2	901.3
Ca	mg/1		150.8
K	mg/1		9.75
bicarbonate	mg/1		189.3
Cd	mg/1		< .001
nitrate nitrite	mg/1		.12
Mg	mg/1		
V	mg/1		.036
Zn	mg/1		<.100
Al	mg/1		
Pb	mg/1		<.005
gross α	pCi/1		580±70
Ra-226	pCi/1	4.3±.1	4.6±.2
Ra-228	pCi/1	0±2	
Pb-210	pCi/1	14±5	
U	mg/1	2.6	2.44

cant water from the mine settling ponds (approximately 2500 gpm in 1977, 1978, and 1979) is sent to an ion exchange facility located at the Kerr-McGee mill site. Mining of ore occurs in all mines except Section 22 and 33, which are undergoing mine water recirculation only. Once the water is run through the ion exchange for uranium recovery, it goes to the mill make-up pond. Most of this water is used in the mill and is disposed of with the mill tailings. Any excess water not sent to the mill is treated with $BaCl_2$ and discharged via an outfall to the Arroyo del Puerto. Since there was no discharge at the time of sampling in 1979, only data for 1977 and 1978 are given for this discharge in Table XIV.

Company officials have stated that at one time or another in the past Section 22, 30 and 30W mines have received backfill. They were not receiving backfill during 1977, 1978, and 1979 however.

United Nuclear Corporation Central Ambrosia Lake Mines

UNC's Westwater Canyon Member host rock mines in the central section of Ambrosia Lake (Ann Lee, Section 27 and Sandstone mines) are all undergoing recirculation of mine water to pick up soluble uranium. The discharges pumped from the three mines are collected together in a pond near the ion exchange facility, which is located at the old Phillips mill site. Water from this pond is run through the ion exchange facility (500 to 600 gpm in 1979) and then most of it is recirculated to the mines to leach

Table XV

United Nuclear Corporation IX

Ambrosia Lake

		10/27/77 Outfall to Arroyo	11/17/78 Last Pond	11/07/79 Last Pond
TSS	mg/l	1.1	< 1.0	2.0
TDS	mg/l	1852	1903	2441
cond	μmhos	2657	2241	3288
pH		8.08		8.12
As	mg/l	< .005	< .005	.009
Ba	mg/l	.27	.074	< .100
Se	mg/l	.268	.171	.122
Mo	mg/l	3.20	1.914	3.06
NH_3	mg/l	.015	0	.05
Na	mg/l	427.8	420.9	510.6
Cl	mg/l	108.1	97.5	188.2
SO_4	mg/l	1060	1115	1279.8
Ca	mg/l		148.8	193.6
K			8.19	9.75
bicarbonate	mg/l		227.7	174.0
Cd	mg/l		< .001	< .001
nitrate nitrite	mg/l		.11	< .01
Mg	mg/l			45.3
V	mg/l		< .010	< .010
Zn	mg/l		< .100	< .250
Al	mg/l			< .250
Pb	mg/l		< .005	< .005
gross α	pCi/l		570±70	360±60
Ra-226	pCi/l	29±1	65±1	19±6
Ra-228	pCi/l	0±2		
Pb-210	pCi/l	17±6		
U	mg/l	.32	2.23	1.31

more uranium, and the rest discharged on the surface. There is no $BaCl_2$ treatment.

In 1977 a discharge observed to be taking place to an arroyo near the ion exchange facility was sampled. However several new ponds to contain IX discharge water have been built since then. By 1979 there was only a very intermittent discharge to the ponds as almost all water was being sent back to the mines. In 1978 and 1979 the sample was obtained in the last IX discharge pond. These data are all shown in Table XV.

The uranium is stripped from the loaded resin at the IX and the pregnant solution sent to the UN-HP mill near Milan.

There has been no backfilling of these three mines with tailings in the past five years, but it is believed that such backfilling may have been practiced in earlier years.

Kerr-McGee Corporation Section 35 and 36 Mines

While UNC's mines discribed above presently have very little net discharge, Kee-McGee's Section 35 and Section 36 mines, completed in the Westwater Canyon Member, have each averaged discharges of about 1300-1600 gpm 1977-1979. During one short period discharge from section 35 was greatly in excess of this due to a break through into the overlying Dakota Sandstone. However in a 1979 underground tour of the mine this flow was noted to have been reduced to a small inflow.

Mill tailings sand from Kerr-McGee's mill has been used for some time for backfill in both 35 and 36. The ore bodies are thick and mining occurs on several levels. Backfilling allows pillars to be pulled while maintaining ground control. The sands are stored near the mine, lifted to the top of a large mixing box containing baffles, mixed with mine water, and the outflow slurry from the box is then carried by steel pipe into the suitably bulkheaded section to be backfilled. The water drains from the sands leaving a stable fill behind. It is reported that mine backfill lowers the natural mine water pH about .5-1 units for mine discharge water during backfill operations.

The discharge from each mine is first sent to settling ponds. After the solids have settled, the water from Section 35 is sent through an ion exchange facility, (loaded resin beads go to the Kerr-McGee mill IX for resin stripping - the pregnant solution from stripping enters the Kerr-McGee mill clarifier.) Then the IX discharge and the Section 36 discharge are collectively treated with $BaCl_2$ (approximately 8 mg $BaCl_2$ per liter of water) and sent through two ponds before discharge. Algae growth is encouraged in the ponds in order to remove radium. The discharge raceway from the last pond was the sampling point for the data given in the first three columns in Table XVI. To indicate treatment effectiveness, the last column presents the data for a

Table XVI

Kerr-McGee Section 35 IX discharge and Sec 36

	10/26/77 Sec 35 & 36 Outfall	11/16/78 Sec 35 & 36 Outfall	11/06/79 Sec 35 & 36 Outfall	11/06/79 Section 35 Raw Mine Water
TSS mg/l	1.08	< 1.0	0	710
TDS mg/l	1231	1247	1242	1323
cond µmhos	1813	1799	1782	1819
pH	8.14		8.22	7.4
As mg/l	<.005	< .005	.007	.030
Ba mg/l	NA	.08	.126	.145
Se mg/l	.027	.059	.066	.238
Mo mg/l	.62	1.047	.515	2.856
NH_3 mg/l	.03	0	0	1.04
Na mg/l	217.4	264.5	269.1	273.7
Cl mg/l	16.7	26.3	20.7	16.1
SO_4 mg/l	705	656.8	704.2	738.0
Ca mg/l		92.0	90.8	92.4
K mg/l		5.85	5.07	6.63
bicarbonate mg/l		246.2	244.0	259.1
Cd mg/l		.008	< .001	.009
nitrate + nitrite		.25	.24	.84
Mg mg/l			26.5	28.6
V mg/l		.025	< .01	.133
Zn mg/l		< .1	<.250	< .250
Al mg/l			< .250	9.58
Pb mg/l		<.005	< .005	< .005
gross α pCi/l		270±40	54±14	1100±100
Ra-226 pCi/l	2.3±.8	2.1±.2	1.4±.4	210±60
Ra-228 pCi/l	0±2			
Pb-210 pCi/l	14±5			
U mg/l	1.1	1.2	.39	5.66

Table XVII

Kerr-McGee Old Backfill Pond

		11/16/78
gross α	pCi/l	1400±100
Ra-226	pCi/l	26±1

raw mine water sample withdrawn at the inlet to the initial settling pond at the Section 35 mine. The temperature of this raw mine water was 20.3°C.

Prior to 1979 there was a pond associated with early sand-slime separations for backfill located near Section 35. The radiological data for this pond, sampled in 1978, is shown in Table XVII. During 1979 Kerr-McGee reclaimed the pond area; it appears that they have not only produced a gently contoured area, but also have reseeded the disturbed surface.

Ranchers Exploration and Development Company Johnny M Mine

Further to the east of Section 36 is the Johnny M mine of Ranchers Exploration and Development Corp. The host rock is the Poison Canyon Member of the Morrison Formation. Backfill using sands from Kerr-McGee's mill with a technique similar to that used at Kerr-McGee's Section 35 and Section 36 mines began in 1977. This mine is relatively young, and in 1977 when the first visit was made, treatment of the discharge was flocculant and batches of $BaCl_2$ addition as the water entered the first of the two unlined settling ponds. Since then a facility for the $BaCl_2$ addition has been built and 100 pounds per day or about 5.5 mg of $BaCl_2$ per liter of inflow water is added. In 1977 the discharge was 800 gpm; in 1978, 1000 gpm; and in 1979, 1500 gpm. Water temperature of the mine water outflow was 21°C. Any treated mine water not taken by the Lee Ranch for irrigation use is piped to a discharge ditch which drains into the Rio San Mateo.

Table XVIII

Ranchers - Johnny M Mine

	10/27/77 Discharge	11/17/78 Discharge	11/07/79 Discharge	11/07/79 Raw Mine Water
TSS mg/l	2.6	7.8	8.0	1088
TDS mg/l	520	511	574	753
cond µmhos	855	737	784	756
pH	8.35		7.94	7.85
As mg/l	.011	.0056	.017	.044
Ba mg/l	NA	.346	1.671	.212
Se mg/l	.008	.061	.043	.128
Mo mg/l	.24	.325	.390	.612
NH_3 mg/l	.115	.125	.03	.36
Na mg/l	101.2	101.2	101.2	101.2
Cl mg/l	8.8	10.2	14.1	8.53
SO_4 mg/l	213.7	204.5	183.7	188.5
Ca mg/l		55.2	55.8	51.6
K mg/l		3.9	3.51	3.90
bicarbonate mg/l		237.4	246.5	256.0
Cd mg/l		$<$.005	$<$.001	$<$ .001
nitrate + nitrite mg/l		.56	.38	.36
Mg mg/l			11.5	15.6
V mg/l		.043	.027	1.408
Zn mg/l		$<$.100	$<$.250	$<$ .250
Al mg/l			.645	17.8
Pb mg/l		$<$.005	$<$.005	.008
gross α pCi/l		1500±100	700±50	1700±100
Ra-226 pCi/l	23.±1	200±10	3.0±.9	
Ra-228 pCi/l	0±2			
Pb-210 pCi/l	33±6			
U mg/l	.67	.76	2.25	5.09

Samples of the discharge (Table XVIII), were taken at the discharge from the last pond. The last column of Table XVIII indicates raw mine water quality in order to show treatment effectiveness. There are no baffles or other mixing devices in the ponds at Johnny M. There is considerable algae growth in the second pond.

Poison Canyon Area (See Figure 3)

There is a discharge in the Poison Canyon area (T13N R9W Sec 30) from a pumped well. This discharge is not associated with any presently active mine. However the high gross alpha concentration in a sample collected in 1978 (Table XIX) would indicate that this well may be completed into an abandoned mine working.

The Hope mine completed in the Todilto Limestone in Poison Canyon makes a very small amount of water. This water is reused in the mine for drill water, etc. The other active mines in the area are dry.

Table XIX

Poison Canyon Well Discharge

		11/16/78
TSS	mg/l	0
TDS	mg/l	1460
cond	µmhos	2426
pH		
As	mg/l	.0115
Ba	mg/l	.074
Se	mg/l	.3116
Mo	mg/l	.015
NH_3	mg/l	.07
Na	mg/l	381.8
Cl	mg/l	38.8
SO4	mg/l	805.5
Ca	mg/l	92.4
K	mg/l	3.51
bicarbonate	mg/l	128.1
Cd	mg/l	.0053
nitrate nitrite	mg/l	5.67
V	mg/l	.047
Zn	mg/l	.170
Al	mg/l	
Pb	mg/l	<.005
gross α	pCi/l	630±70
Ra-226	pCi/l	1.2±.1
U	mg/l	1.27

Laguna-Cebolleta Area (See Figure 4)

Anaconda Company P-10 Mine

The P-10 is an underground decline located near the Jackpile-Paguate open pit mine operated by Anaconda Company. The host rock is the Jackpile sandstone. Water from the mine is sent to an unlined holding pond for use as dust control on mine roads, etc. In 1977 the discharge was 150 gpm, which declined to 104 gpm in 1979. Samples collected in 1977 and 1978 were taken from the holding pond (which was in a different location in 1978). Data obtained from these samples are shown in Table XX.

Sohio Western Mining Company JJ #1 Mine

North of P-10 but still mining from the Jackpile sandstone is Sohio's JJ #1 mine. The dewatering rates are small: 30-40 gpm in 1977; 25 gpm in 1978; and 25 gpm in 1979. The discharge is sent to two settling-storage ponds before being used in the nearby mill grinding circuit. The samples (Table XXI) were taken from the settling pond. Since the water is not discharged, no attempt is made to induce extensive settling, and hence, as is seen in the data, the suspended solids level is quite high.

At the time the samples were taken backfill had not been started at the JJ #1, and there had been no mine water recirculation.

Table XX

Anaconda P-10 Mine

	11/15/77[1] holding pond	11/27/78[2] holding pond
TSS mg/l	23	1862.5
TDS mg/l	1675	812
cond µmhos	2394	1517
pH	8.44	
As mg/l	.005	.0104
Ba mg/l		.100
Se mg/l	.043	.028
Mo mg/l	.545	.740
NH_3 mg/l	.04	.21
Na mg/l	503.7	338.1
Cl mg/l	15.6	17.2
SO_4 mg/l	842.4	375.2
Ca mg/l		15.6
K mg/l		5.85
bicarbonate mg/l		441.4
Cd mg/l		.0012
nitrate nitrite mg/l		1.48
V mg/l		.880
Zn mg/l		.300
Pb mg/l		.017
gross α pCi/l		2700±100
Ra-226 pCi/l	220±20	460±10
Ra-228 pCi/l	0±2	
Pb-210 pCi/l	26±6	
U mg/l	2.6	4.79

1 P-10 pond, lower location

2 P-10 holding pond - moved up to higher location

Table XXI

Sohio JJ #1 Mine

	11/27/78 settling pond	11/08/79 settling pond
TSS mg/l	2563	6264
TDS mg/l	952	893
cond µmhos	1294	1360
pH		8.3
As mg/l	< .021	.022
Ba mg/l	.160	.251
Se mg/l	< .005	.007
Mo mg/l	.134	< .010
NH_3 mg/l	2.51	.82
Na mg/l	294.4	296.7
Cl mg/l	15.0	23
SO_4 mg/l	209.1	251.5
Ca mg/l	9.0	10.8
K mg/l	7.02	4.29
bicarbonate mg/l	NA	571.0
Cd mg/l	.003	.002
nitrate nitrite mg/l	1.47	2.7
Mg mg/l		6.0
V mg/l	.130	3.53
Zn mg/l	.200	.474
Al mg/l		136.0
Pb mg/l	.007	.150
gross α pCi/l	9000±300	3500±100
Ra-226 pCi/l	98±1	310±90
U mg/l	11.1	31.5

United Nuclear Corp. St. Anthony Mine

Close to JJ #1 and also mining in the Jackpile sandstone is UNC's St. Anthony open pit mine and underground mine. In 1977 the pit was making 30-50 gpm. This water was pumped to a surge pond which sometimes overflowed into the arroyo. The 1977 sample was obtained at the overflow point (Table XXII). In 1978 a holding pond was installed to hold the 1978 pit make of 20-30 gpm and the 1979 pit make of up to 20 gpm, and eliminate the discharge into the arroyo. The 1978 sample was obtained from the holding pond. During the 1979 EID visit no sample was taken of pit water because of extremely muddy road conditions.

The underground mine was under development in 1977 and 1978, and was placed into production in 1979. Discharges were: 1977 - 2-3 gpm, 1978 - 25 gpm, and 1979 - 20 gpm. Presently the mine water goes to a series of holding ponds. The most recent samples were obtained from the last of these ponds (Table XXIII). Water from all ponds (pit and shaft) is used for dust control, etc.

Table XXII

United Nuclear Corporation St. Anthony Open Pit Mine

(sump water from pit)

	10/26/77	11/16/78
TSS mg/l	168	166.6
TDS mg/l	1378	2493
cond µmhos	4549	3998
pH	8.18	
As mg/l	.005	<.005
Ba mg/l		.100
Se mg/l	.019	<.005
Mo mg/l	.018	.0096
NH_3 mg/l	.86	.35
Na mg/l	724.5	641.7
Cl mg/l	23.5	20.1
SO_4 mg/l	2151.1	2038.3
Ca mg/l		168.4
K mg/l		5.07
bicarbonate mg/l		284.7
Cd mg/l		< .001
nitrate nitrite mg/l		2.25
V mg/l		.027
Zn mg/l		.020
Pb mg/l		< .005
gross α pCi/l		2100±200
Ra-226 pCi/l	180±20	90±1
Ra-228 pCi/l	0±2	
Pb-210 pCi/l	17±5	
U mg/l	2.5	5.51

Table XXIII

United Nuclear Corp. St. Anthony Shaft (last pond)

	11/28/78*	11/08/79
TSS mg/l	68.15	211
TDS mg/l	1272	887
cond μmhos	1823	1269
pH		7.57
As mg/l	.0072	.008
Ba mg/l	.100	.10
Se mg/l	.025	<.005
Mo mg/l	.792	.547
NH_3 mg/l	.92	.37
Na mg/l	361.1	262.2
Cl mg/l	34.1	21.6
SO_4 mg/l	530.3	272.4
Ca mg/l	38.4	12.8
K mg/l	4.29	8.19
bicarbonate mg/l	398.5	419.5
Cd mg/l	<.001	< .001
nitrate nitrite mg/l	5.81	1.69
Mg mg/l		5.0
V mg/l	.218	1.408
Zn mg/l	.010	< .250
Al mg/l		15.990
Pb mg/l	<.005	.014
gross α pCi/l	4100±200	5100±300
Ra-226 pCi/l	40±1	450±140
Ra-228 pCi/l		
Pb-210 pCi/l		
U mg/l	1.01	5.37

* under development

B. MINES UNDER DEVELOPMENT

Crownpoint - Nose Rock Area (See Figure 2)

Phillips Uranium Corporation Nose Rock Mines

Phillips has a large, deep (greater than 3000 feet) mine complex of three shafts undergoing development into the Westwater Canyon Member in the Nose Rock area. In 1977 development had just begun with two of the shaft collars in place and headframes being installed. Dewatering wells were being drilled around the shaft area, but there was not yet any discharge. By the fall of 1978 both of the shafts were down about 1000 feet and grouting of the Hosta Tongue of the Point Lookout sandstone was proceeding. The dewatering wells which had been completed into the Point Lookout were being deepened. One shaft was dewatering at approximately 85 gpm and the other at 60-120 gpm. The wells dewatered at 200-700 gpm during the year, with 550-600 gpm being averaged in late fall.

By November 2, 1979 the 18'2" production shaft was down to 2057 feet below land surface, the smaller 16' vent shaft was down to 1545 feet and the collar and headframe were installed on shaft #3. The dewatering wells had been deepened to preceed progress in the shafts with the shaft 1 and shaft 2 wells now in the Dakota, and the shaft 3 wells in the Point Lookout. About 300-500 gpm of water was being produced (total) from the three shafts and 1800 gpm from the dewatering wells.

Table XXIV

Phillips Nose Rock (under development)

	11/14/78[1]	11/14/78[2]	11/02/79[2]
TSS mg/l	8.6	10.48	54
TDS mg/l	1577	1771	1522
cond μmhos	2355	2483	2423
pH			9.37
As mg/l	<.005	<.005	.006
Ba mg/l	.059	.048	< .100
Se mg/l	<.005	.103	.005
Mo mg/l	.0069	.0027	< .010
NH_3 mg/l	13.0	53.5	.59
Na mg/l	494.5	524.4	529.0
Cl mg/l	96.8	53.3	138.3
SO_4 mg/l	678.1	834.7	618.4
Ca mg/l	26.8	15.6	3.6
K mg/l	3.51	6.24	2.73
bicarbonate mg/l	357.9	108.1	306.9
Cd mg/l	< .005	< .001	< .001
nitrate nitrite mg/l	.17	.64	.5
Mg mg/l			214
V mg/l	.015	.0165	.0105
Zn mg/l	< .100	.100	< .250
Al mg/l			3.030
Pb mg/l	.005	< .005	< .005
gross pCi/l	0±2.5	1400±100	15±9
Ra-226 pCi/l	.97±.10	5.2±.2	< .09
Pb pCi/l			
U mg/l	<.010	<.010	<.005

1 mine shaft

2 shaft and dewatering wells

Shaft water has always been discharged to settling ponds with flocculant added to promote settling. No $BaCl_2$ treatment has been necessary yet. The discharge from these ponds and the discharge from the wells meet in a common discharge into Kim-me-ni-oli Wash. Table XXIV indicates data obtained during the two years in which there has been a discharge. In 1979 only the combined final discharge was sampled, while in 1978 a separate sample was also taken of the shaft water after settling.

East Ambrosia Lake - West Mt. Taylor Area (See Figure 3)

Gulf Mineral Resources Corporation Mt. Taylor Mine

Gulf has a deep underground mine complex (presently two shafts) undergoing development near San Mateo. The ore is at a depth of 3200 to 3300 feet, mainly in the upper Westwater Member, but with some in the lower Westwater. By October 1977 the 24' production shaft had reached a depth of 2300 feet and the 14' service #1 shaft a depth of 2600 feet. The shallow dewatering wells were no longer pumping. Deeper wells were pumping a total of approximately 1200 gpm and each shaft was being dewatered at 450 gpm. At this stage in development only two lined (30 mil hypalon) ponds 75' x 175' x 10' were being used as settling ponds for the shaft water, and shaft and dewatering well discharges were going into San Mateo Creek. Samples were taken of treated shaft water at its outfall and of dewatering well water at its outfall.

By the next fall in November 1978, shaft #1 was down to 3,100 feet and shaft #2 was at 3,130 feet (top of the Westwater). Total production from dewatering wells was 970 to 1020 gpm and the two shafts were making a total of approximately 4000 gpm, with about half of this coming from each shaft. Additional settling ponds had been installed, and the discharge point had been relocated to San Lucas Canyon, a tributary of the Rio Puerco of the East. Samples were taken of the combined discharge at the outfall pipe.

By the fall of 1979 the #1 shaft had been completed into the ore zone, and an experimental mining program had been completed. Ground conditions were found to be good. The #2 shaft (production) was down to 3200 feet below land surface with a target of 3370 feet. It is possible that two more shafts may be constructed but these had not yet been started. Dewatering wells were no longer in use and the mine shafts were being dewatered at a total net inflow of 4000 gpm (pumping rate was 5200 gpm because mine water was being reused for drill water, pump gland water etc.). At the time of the November 1979 visit, an ion exchange plant for uranium removal was under construction. Barium chloride and flocculant were being added for suspended solids and radium removal, and acid was being added to bring down the pH. In November 1979, 35 mg of $BaCl_2$ was being added per liter of mine water. (This rate was subsequently reduced to an average of 26.4 mg/1 by March 1980). The raw mine water was being pumped from the shafts at a temperature of 36°C. Samples were taken of treated effluent at the outfall pipe and of raw mine water where it entered the first settling pond.

Data for all three years sampling are found in Table XXV.

By April 1980 both shafts had been completed. Work was in progress on station completion and installing the necessary equipment for hoisting waste and ore. A minimum amount of drifting was taking place.

East Mount Taylor - Rio Puerco Area (See Figure 4)

Bokum Resources Corp. Marquez Mine

To the east of the Gulf Mt. Taylor mine, in the eastern environs of Mt. Taylor, Bokum Resources Corp. has had a mine under development at Marquez. Again the target host rock is the Westwater Canyon Member (about 1985 feet below land surface). On November 15, 1977 the 14 foot inside diameter shaft had reached a depth of 1458 feet. No dewatering wells had been drilled. All discharge (70-80 gpm) was therefore from the shaft. The discharge entered ponds with the overflow going into the adjacent stream bed of the Rio Marquez, a tributary of the Rio Puerco of the East.

During the fall visit of 1978 it was found that shaft sinking operations had been discontinued at 1795 feet, because of the

Table XXV

Gulf Mt. Taylor Mine (under development)

	10/27/77[1]	10/27/77[2]	11/15/78[3]	11/05/79[4]	11/05/79[5]
TSS mg/l	< 1	23.75	56.1	5	18
TDS mg/l	601	620	619	690	696
cond µmhos	970	1022	1061	1050	1061
pH	8.7	8.83		6.62	9.02
As mg/l	<.005	<.005	.0127	.009	.007
Ba mg/l			.136	.363	.149
Se mg/l	.003	.003	.0055	.029	.018
Mo mg/l	< .01	< .01	.108	.034	.130
NH_3 mg/l	.098	.039	.11	.54	.08
Na mg/l	216.2	225.4	227.7	232.3	225.4
Cl mg/l	18.6	21.3	10.0	24.0	11.9
SO_4 mg/l	143.5	134.1	236.6	270.2	251.9
Ca mg/l			6.0	4.8	3.2
K mg/l			2.34	1.56	1.56
bicarbonate mg/l			276.9	157.3	246.0
Cd mg/l			<.001	<.001	<.001
nitrate nitrite mg/l			.17	.19	.25
Mg mg/l				.4	0
V mg/l			.018	<.010	<.010
Zn mg/l			<.100	<.250	<.250
Al mg/l				.470	1.12
Pb mg/l			<.005	<.005	<.005
gross α pCi/l			35±16	430±40	990±50
Ra-226 pCi/l	.2±.1	.7±.6	2.4±.1	.12±.04	17±5
Ra-228 pCi/l	0±2	0±2			
Pb-210 pCi/l	0±2	10±5			
U mg/l	.08	.03	<.010	.19	.450

[1] dewatering well

[2] shaft dewatering

[3] shaft & 4 wells

[4] treated mine water at outfall pipe near settling ponds

[5] raw mine water from shaft

large inflow of water encountered. The shaft was then estimated to be making about 1200 gpm.

Dewatering problems continued and the main shaft was still at 1795 feet when the mine was visited in November 1979. A 72 inch drilled diameter ventilation shaft was being put in, and it had reached 2060 feet, almost to its eventual depth of about 2100 feet. Larger pumps had been installed and about 1034 gpm total was being pumped. It was estimated that the Westwater was contributing about 800 gpm of this. As larger pumps had been installed it was anticipated by Bokum staff that further shaft sinking progress would be made soon.

Also by the fall of 1979 a pipeline had been put in to carry the mine water to the site of the Bokum Mill then under construction, and the mine water was being discharged from the end of this pipeline into Seco Canyon, a tributary of the Rio Marquez. The mine water's only treatment is settling ponds. The data for the discharge from this mine are given in Table XXVI. The temperature of the raw mine water being pumped from the shaft in 1978 was 39°C, and in 1979 the discharge from the end of the pipeline into Seco Canyon was 33.5°C.

Table XXVI

Bokum Marquez Mine (under development)

	11/15/77	11/28/78[1]	11/09/79[2]
TSS mg/l	553.5	205.9	8
TDS mg/l	612	1128	1190
cond µmhos	934	1646	1760
pH	8.73		8.43
As mg/l	.012	<.005	<.005
Ba mg/l		<.100	<.100
Se mg/l	<.005	<.005	.005
Mo mg/l	.007	.0048	<.010
NH_3 mg/l	1.24	.28	.40
Na mg/l	209.3	357.7	361.1
Cl mg/l	24.0	35.2	38.7
SO_4 mg/l	527.2	501.4	574.6
Ca mg/l		23.6	25.8
K mg/l		4.48	3.9
bicarbonate mg/l		285.5	277.8
Cd mg/l		.0022	<.001
nitrate nitrite mg/l		.08	.18
Mg mg/l			.6
V mg/l		<.010	<.010
Zn mg/l		.030	<.250
Al mg/l			.530
Pb mg/l		<.005	<.005
gross α pCi/l		11±8	450±40
Ra-226 pCi/l	29±4	2.8±.1	.21±.06
Ra-228 pCi/l	0±2		
Pb pCi/l	0±2		
U mg/l	< .01	<.005	<.005

1 influent to first settling pond

2 final discharge after settling

Kerr-McGee Corporation Rio Puerco Mine

A new mining area appears to be developing in the area of the Rio Puerco of the East. Kerr-McGee had their Rio Puerco mine under development in that area during 1977, 1978, and 1979. Target host rock is the Westwater Canyon sandstone composed of four sandstone members separated by shales in this region. The uranium ore is located in the lower three members. No dewatering wells were used at this site and all water was pumped from the shaft area. In the fall of 1977 the shaft was at a depth of 571 feet and dewatering was 60 gpm. By 1978 dewatering had increased to 500 gpm as shaft sinking progressed.

By 1979, when the target depth of slightly over 800 feet had been obtained, the dewatering rate was 1422 gpm. Ground conditions were found to be good as haulageways and development drilling was extended outwards. However the dewatering rate was much greater than expected. It has been reported by Kerr-McGee that approximately 90-95% of the mine dewatering water would come from the Westwater Canyon and 5-10% from the Jackpile sandstone.

In 1977 the only mine water treatment was a temporary settling pond. In 1978 and 1979 the water was being discharged into a series of ponds. Flocculant was being added at the entrance to the first pond, and 10 mg of $BaCl_2$ was being added per liter of mine water at the entrance to the second pond.

Table XXVII

Kerr-McGee Rio Puerco Mine

(under development)

	11/16/77[1]	11/29/78[2]	11/09/79[2,3]	11/09/79[4]
TSS mg/l	51.5	15.52	9	138
TDS mg/l	1405	1231	1154	1136
cond µmhos	2633	1764	1730	1772
pH	11.55		8.35	8.29
As mg/l	.005	<.005	<.005	<.005
Ba mg/l		<.100	.831	.118
Se mg/l	.004	<.005	.024	.044
Mo mg/l		.0089	.678	.884
NH_3 mg/l	.49	.20	.22	.38
Na mg/l	418.6	395.6	368.0	361.1
Cl mg/l	19.8	30.0	34.1	30.6
SO_4 mg/l	744	547.2	530.5	532.3
Ca mg/l		11.6	19.2	20.8
K mg/l		3.51	1.56	2.34
bicarbonate mg/l		268.4	332.7	353.4
Cd mg/l		.0064	<.001	<.001
nitrate nitrite mg/l		.18	.28	.22
Mg mg/l			3.7	0
V mg/l		.012	<.010	.095
Zn mg/l		.010	<.250	<.250
Al mg/l			.290	2.075
Pb mg/l		<.005	<.005	<.005
gross α pCi/l		110±30	190±60	940±130
Ra-226 pCi/l	14±3	1.6±.1	1.6±.5	15±4
Ra-228 pCi/l	0±2			
Pb-210 pCi/l	15±5			
U mg/l	.02	.010	.220	.510

1 outfall from temporary settling pond

2 treated - settling, floc, $BaCl_2$ - sample taken at discharge sump

3 shaft complete, mine almost ready for production

4 raw

Final discharge was into a tributary of the Rio Salado which is tributary to the Rio Puerco of the East. All final discharge samples were obtained at the discharge of the last pond in use at the time of sampling. The raw mine water sample was obtained from the inflow pipe from the mine to the first pond. These data are found in Table XXVII. In early 1980 the mine was placed on standby and all pumping was discontinued, thus allowing the mine to flood.

C. BASELINE GROUND WATER DATA

East Mount Taylor - Rio Puerco Area (See Figure 4)

Conoco (Continental Oil Co.) Bernabe Project

On November 29, 1978 a sample was obtained from a well drilled into the target Westwater ore body horizon (approximately 2000 feet deep) for the Bernabe (Continental Oil) project in T 12N R 2W Section 36 near the Rio Puerco of the East. The data are given in Table XXVIII. The water temperature was 33°C.

Crownpoint - Nose Rock Area (See Figure 2)

Mobil Oil Corp., Crownpoint Section 9 Pilot In-Situ Leach Project

Data (Table XXIX) were obtained from a set of samples taken November 2, 1979 from wells at Mobil's pilot in-situ leach project in T 17N R13W Section 9 before any chemicals were added. These samples are all from the Westwater and all samples were filtered. The completed depths of all wells sampled was approximately 2100'. Injection of leaching chemicals at this facility was started November 6, 1979.

Table XXVIII

Conoco Bernabe - Artesian Well[1] - Baseline

	11/29/78
TSS mg/l	6.4
TDS mg/l	8412
cond µmhos	11525
pH	
As mg/l	.028
Ba mg/l	<.100
Se mg/l	<.005
Mo mg/l	.0095
NH_3 mg/l	1.53
Na mg/l	2764.6
Cl mg/l	1863.0
SO_4 mg/l	3193.6
K mg/l	8.58
bicarbonate mg/l	373.3
Cd mg/l	.003
nitrate nitrite mg/l	.01
V mg/l	.070
Zn mg/l	.020
Pb mg/l	<.005
Ca mg/l	70.6
gross α pCi/l	82±48
Ra-226 pCi/l	37±1
U mg/l	<.005

1 Well completed 1800 ft. Artesian flow.
T 12N R1W Section 36

Table XXIX

Mobil Oil - Crownpoint In Situ Baseline[1,2]
November 2, 1979

	Well 225	Well 222	Well 224	Well 202	Well 211	Well 216
TSS mg/l	filtered	filtered	filtered	filtered	filtered	filtered
TDS mg/l	371	481	312	321	372	321
As mg/l	<.005	.005	<.005	<.005	.008	.006
Ba mg/l	.100	.100	.100	.193	.164	.116
Se mg/l	< .005	<.005	<.005	< .005	<.005	<.005
Mo mg/l	< .010	<.010	<.010	< .010	<.010	.018
Na mg/l	110.4	117.3	110.4	110.4	128.8	112.7
Cl mg/l	2.8	2.1	4.6	5.9	23.3	7.2
SO_4 mg/l	35.0	36.4	36.8	33.3	41.2	39.4
Ca mg/l	1.6	1.2	2.0	2.0	4.4	1.2
K mg/l	.39	.39	.39	.39	.78	0
bicarbonate mg/l	237.3	240.4	231.6	246.4	274.7	237.8
Cd mg/l	.001	<.001	<.001	< .001	<.001	<.001
Mg mg/l	.1	.2	∼ 0	∼ 0	.016	.2
V mg/l	< .010	<.010	<.010	<.010	<.010	<.010
Zn mg/l	<.250	<.250	<.250	<.250	<.250	<.250
Al mg/l	<.250	<.250	<.250	<.250	<.250	<.250
Pb mg/l	<.005	<.005	<.005	<.005	<.005	<.005
gross α pCi/l	350±30	36±12	250±30	17±9	180±20	120±20
Ra-226 pCi/l	9.4±2.8	3.9±1.2	1.8±.5	.65±.2	53±16	3.8±1.1
U mg/l	<.005	<.005	< .005	<.005	< .005	.009

1 Wells pumped 24 hours - all samples filtered

2 Since all samples were filtered analysis was for dissolved

D. ACTIVE MILLS

The five uranium mills which were licensed and operating at the time of data collection are:

Anaconda Company Bluewater Mill, near Bluewater, Valencia County, New Mexico, (See Figure 3 on page 4)

Kerr-McGee Corporation Mill in the Ambrosia Lake Area, McKinley County, New Mexico, (See Figure 3 on page 4)

Sohio Western Mining Company, L Bar Mill near Seboyeta (Cebolleta), Valencia County, New Mexico, (See Figure 4 on page 5)

United Nuclear Company (UNC) Church Rock Mill, northeast of Gallup, McKinley County, New Mexico, (See Figure 2 on page 3)

United Nuclear-Homestake Partners (UN-HP) Mill near Milan, Valencia County, New Mexico, (See Figure 3 on page 4)

Every mill tailings pond liquor was sampled. Those data are tabulated in Tables XXX through XXXIV. All mills use an acid circuit except UN-HP. UN-HP recovers vanadium as well as uranium, while Kerr-McGee recovers molybdenum (Mo). Anaconda reports no problem with Mo buildup. Neither UNC or Sohio recover Mo. Both UNC and Kerr-McGee obtain their process water from mine dewatering. Anaconda, Sohio, (with the exception of the small mine discharge previously described) and UN-HP obtain their water from wells drilled near each mill. Kerr-McGee and Anaconda both decant excess tailings liquor into large synthetically lined evaporation ponds, and Kerr-McGee also uses some older unlined decant ponds. During the 1979 visit to UNC, UNC was also decanting to a then unlined pond. Operation of the UNC mill tailings area had been altered due to a break in the tailings dam on July 16, 1979.

Table XXX

Anaconda Bluewater Mill - Tailings Liquor

	10/26/77	11/17/78	11/07/79
TSS mg/l	20.5		52
TDS mg/l	17850		37275
cond µmhos	19635	54285	65714
pH	2.15		.87
As mg/l	.62	3.0645	3.07
Ba mg/l	.55	.187	.241
Se mg/l	.006	.0702	6.966
Mo mg/l	.16	.6936	.955
NH_3 mg/l	56.9	105.25	106.0
Na mg/l	2118.3	1738	1111.0
Cl mg/l	3111.9	2354.3	1251.2
SO_4 mg/l	8521.6	22,792	33,812
Ca mg/l		688.0	320.0
K mg/l		100.62	126.4
Cd mg/l		.0972	.096
nitrate nitrite mg/l		14.11	< .01
Mg mg/l			2101
V mg/l		43.9	48.96
Zn mg/l		12.390	< .250
Al mg/l			1120
Pb mg/l		.0554	1.440
gross α pCi/l		45000±2000	2200±100
Ra-226 pCi/l	1800±100	50±2	15±4
Ra-228 pCi/l	0±2		
Pb-210 pCi/l	1200±100		
U mg/l	53.0	47.62	18.5

Table XXXI

Kerr-McGee Ambrosia Lake Mill - Decant from Tailings Pond

	11/16/78	11/06/79
TSS mg/l		98
TDS mg/l		40002
cond µmhos		45,320
pH		1.33
As mg/l	5.586	2.87
Ba mg/l	.150	.231
Se mg/l	.700	2.788
Mo mg/l	1.429	21.822
NH_3 mg/l	396.0	368
Na mg/l	1759.5	1895
Cl mg/l	2250.2	2199.6
SO_4 mg/l	24,476	29,819
Ca mg/l	432.0	224.0
K mg/l	82.68	97.9
Cd mg/l	.0263	.018
nitrate nitrite mg/l	9.03	15.64
Mg mg/l		1777
V mg/l	85.5	106.75
Zn mg/l	7.05	6.910
Al mg/l		1,250
Pb mg/l	.996	1.615
gross α pCi/l	73000±2000	8300±400
Ra-226 pCi/l	160±10	51±15
Ra-228 pCi/l		
Pb-210 pCi/l		
U mg/l	16.2	13.4

Table XXXII

Sohio Mill - Tailings Pond Liquor[1]

	11/15/77	11/27/78	11/08/79
TSS mg/l	371		263
TDS mg/l	32056	46104	39760
cond µmhos	71820	89,376	71523
pH	.96		.98
As mg/l	1.108	1.594	1.110
Ba mg/l		.110	.301
Se mg/l	.33	.065	4.181
Mo mg/l	.679	.332	.310
NH_3 mg/l	507.37	466.0	199.0
Na mg/l	1203	1662.9	926.9
Cl mg/l	529.9	660.5	370.9
SO_4 mg/l	303.8	57824.3	36865
Ca mg/l			352.0
K mg/l		182.13	96.3
Cd mg/l		.050	.019
nitrate nitrite mg/l		6.02	2.22
Mg mg/l			1275
V mg/l		102.0	48.33
Zn mg/l		6.2	5.24
Al mg/l			1,110
Pb mg/l		1.991	2.150
gross α pCi/l		9000±300	31000±2000
Ra-226 pCi/l	180±20	98±1	25±8
Ra-228 pCi/l	38±10		
Pb-210 pCi/l	1800±100		
U mg/l	1.1	23.3	4.23

[1] Sample from decant line sump

Table XXXIII

UNC Mill - Tailings Pond Liquor

	11/13/78[1]	11/01/79[2]
TSS mg/l		435
TDS mg/l		39043
cond µmhos		40788
pH		1.33
As mg/l	1.235	1.870
Ba mg/l	.183	.372
Se mg/l	.0934	.450
Mo mg/l	2.123	1.659
NH_3 mg/l	453.0	3.32
Na mg/l	595.7	549.7
Cl mg/l	320.9	296.8
SO_4 mg/l	1363	28,876
Ca mg/l	513.6	544.0
K mg/l	99.84	82.3
nitrate nitrite mg/l	3.97	2.03
Mg mg/l		1205
V mg/l	39.25	56.630
Zn mg/l	9.37	8.25
Al mg/l		1220
Pb mg/l	.545	.875
Cd mg/l	.0094	.014
gross α pCi/l	62000±3000	43000±2000
Ra-226 pCi/l	88±2	27±8
Ra-228 pCi/l		
Pb pCi/l		
U mg/l	9.39	11.4

1 North pond

2 West Borrow pit decant

Table XXXIV

UN-HP Mill - Sump for Tailings Pond Water Drainage

	10/26/77	11/16/78	11/06/79
TSS mg/l	32.0	52.0	44.0
TDS mg/l	17035	20710	25400
cond µmhos	20790	23990	28840
pH	10.12		10.32
As mg/l	2.86	7.192	5.020
Ba mg/l	<.100	.051	<.100
Se mg/l	51.18	31.160	27.88
Mo mg/l	72.0	105.201	104.5
NH_3 mg/l	11.23	13.9	17.8
Na mg/l	6141.0	8464	9292
Cl mg/l	793.2	1014.1	1418
SO_4 mg/l	5531.6	8346	8411.5
Ca mg/l		10.0	60.0
K mg/l		31.2	35.1
bicarbonate mg/l			2388
Cd mg/l		.0277	.001
nitrate nitrite mg/l		22.42	10.72
Mg mg/l			813.0
V mg/l		13.6	1.18
Zn mg/l		<.100	<.250
Al mg/l			<.250
Pb mg/l		<.005	.007
gross α pCi/l		10000±1000	3400±400
Ra-226 pCi/l	58±4	90±1	56±17
Ra-228 pCi/l	0±2		
Pb-210 pCi/l	49±8		
U mg/l	44.0	52.8	4.17

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5. Environmental Assessment NPDES Permit Application for Nose Rock Project McKinley County New Mexico, Phillips Petroleum Company and Dames and Moore, January 1977.

6. Letter from William L. Chenoweth, DOE Grand Junction to Betty Perkins, New Mexico Energy and Minerals Department, August 14, 1979.

7. Hearing before the State Engineer, July 31 - August 2, 1979 Phillips Uranium Company Exhibit.

8. William L Chenoweth, personal communication.

APPENDIX: Abbreviations and Symbols Used

HED	Health and Environment Department (New Mexico)
EID	Environmental Improvement Division (New Mexico)
EMD	Energy and Minerals Department (New Mexico)
SLD	Scientific Laboratory Division (New Mexico)
EPA	Environmental Protection Agency (Federal)
NPDES	National Pollutant Discharge Elimination System (under the Federal Clean Water Act)
IX	Ion Exchange Facility
mg/l	Milligrams per liter
pCi/l	Picocuries per liter ($1 pCi = 1 \times 10^{-12}$ Curie) (1 Curie $= 3.7 \times 10^{10}$ radioactive disintegrations per second)
Gross α	Gross alpha
TSS	Total Suspended Solids (Total nonfilterable residue)
TDS	Total Dissolved Solids (Total filterable residue)
Cond.	Conductivity
Al	Aluminum
As	Arsenic
Ba	Barium
Ca	Calcuim
Cd	Cadmuim
Cl	Chloride
K	Potassium
Mg	Magnesium
Mo	Molybdenum
Na	Sodium
NH_3	Ammonia
NO_3	Nitrate
NO_2	Nitrite
Pb	Lead
Ra	Radium
Se	Selenuim
SO_4	Sulfate
U	Uranium
V	Vanaduim
Zn	Zinc